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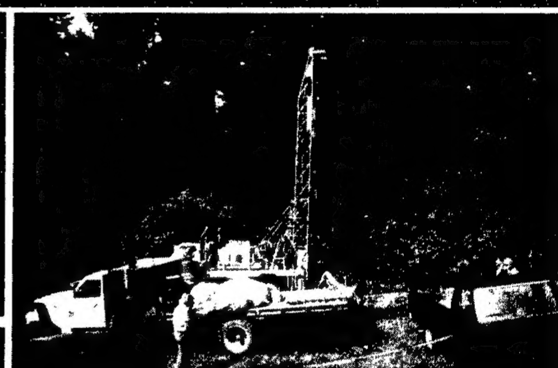
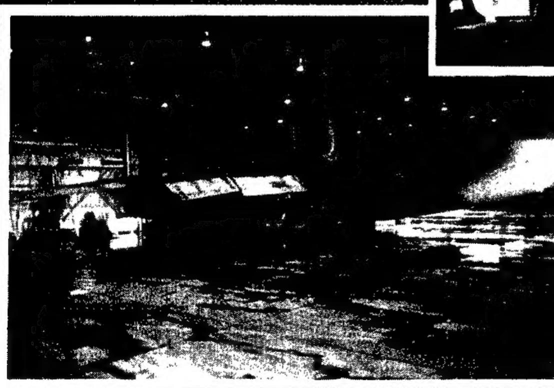
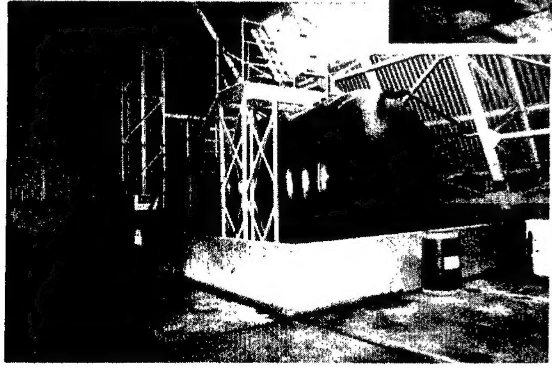
WINTER
1991

AIR FORCE JOURNAL of LOGISTICS



The Air Force's Role in Saving the Environment





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COVER (TOP TO BOTTOM):

Pic 1. Emergency spill catchment boom in event of accidental petroleum release.

Pic 2. Installation of groundwater monitoring well.

Pic 3. Inside aircraft washrack which generates a solvent rinsate that is a hazardous waste.

Pic 4. Washrack contractor which collects rinsate.

(Photos Courtesy of McChord AFB)

AFRP 400-1

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Acquisition

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Commander
Air Force Logistics Command

Lieutenant General Henry Viccellio, Jr.
Deputy Chief of Staff
Logistics and Engineering, HQ USAF

Colonel Russell G. Stafford
Commander
Air Force Logistics Management Center

Editors

Lieutenant Colonel David M. Rigsbee
Jane S. Allen, Assistant
Air Force Logistics Management Center

Graphics

Ms Peggy Greenlee

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The past few years have produced a revolutionary change in global politics. From the new European governments' strong environmental orientation to the unprecedented global consensus on a treaty to protect the ozone layer, green is the new political landscape of the 1990s. The Air Force must respond to this trend in visible and substantive ways if we expect to retain the support of Congress and the people.

Greening of Global and National Politics

In 1987, over 30 countries signed a treaty called the Montreal Protocol on Substances that Deplete the Ozone Layer. The treaty required modest reductions in chemicals believed to deplete the earth's ozone layer. In June 1990, the treaty was renegotiated, expanding the list of chemicals and requiring a complete ban on most by the year 2000. The list of signatory countries grew to over 90. Despite the high cost of compliance, not a single country entered an objecting opinion for the record.

In eastern Europe especially, the environmental movement is growing. Many of the new governments taking over from toppling communist regimes have "green" roots. The new democratic leadership in East Germany decided to close some of its most polluting factories and suffer the economic loss and unemployment rather than tolerate the continued fouling of its country. At the same time, reports are surfacing of alleged Air Force environmental "atrocities" in Europe. We've been charged with dumping jet fuel and other hazardous materials into streams and leaking carcinogens into water sources. Two countries are prosecuting civilian employees of the US military.[1] Such accusations, right or wrong, are likely to embarrass us at home and undermine US foreign policy objectives.

The environment is moving to the top of the domestic political agenda too. The House and Senate recently passed similar versions of a new Clean Air Act, the first major revision since it was enacted in 1970. Estimates of the cost to the public and industry vary widely, but the consensus is it will not be cheap and some industries may be forced to close. Yet Congress passed this major piece of expensive legislation because Americans are willing to pay for a clean environment. The message to the military is that the environment is a precious national resource and needs defending. This view is reflected in the Nunn amendment to the FY91 DOD Authorization Act which "broadens the definition of national security to include threats to the environment."[2]

The legitimacy of environment as a national defense role is also reflected in changes to DOD and Air Force policy. Secretary of Defense Cheney's 10 October 1989 memo on Environmental Management Policy said, "I want the Department of Defense to be the Federal leader in agency environmental compliance and protection." Additional leadership emphasis was provided by Lieutenant General Henry Viccellio, Jr., Deputy Chief of Staff, Logistics and Engineering, Headquarters USAF, in a 27 October 1989 letter on Environmental Management Policy. In it he called for a change in mindset across the Air Force. He said protecting and enhancing the environment needs to become a habit and part of our mental checklist, and we must add an environmental perspective to our definition of excellence. In response to this leadership focus, Major General Joseph A. Ahearn, Director of Engineering and Services, Headquarters USAF, developed and conducted the first ever Air Force Environmental Leadership Course for senior commanders and coined the phrase "protectors of the environment." The notion is that compliance is the minimum acceptable standard and the Air Force should do more where possible.

Need for a Strategy

Attention to environment is also essential if we hope to secure the resources we need from the public to accomplish our mission. If the Air Force is to secure continued public and Congressional support, behavior must change. We must respond by conducting our missions in an environmentally responsible manner. Congress has indicated funding support for environmental initiatives, in contrast to reducing defense outlays by 25%. Senator Sam Nunn recently addressed this shift by indicating a Congressional willingness to permit the military to retain some of the "peace dividend" for environmental purposes. The Senator announced the Senate Armed Services Committee has formed a Defense Environmental Research Council as part of the National Defense Authorization Act for Fiscal Year 1991 to address a variety of defense environmental issues. He also announced a "plus up" of $250 million for waste cleanup at military facilities.[3]

Now it is time for us to act more than ever before. We have an opportunity to develop a plan and work with Congress to obtain resources. It is our best hope to retain funding in this deficit budget climate. The key to making this strategy work is to combine our mission requirements with Congressional demands for environmentally responsible behavior. Such a strategy should turn rhetoric into action. It will require a commitment and a change in perspective at all levels of command. We must believe our missions will be enhanced by protecting the environment, rather than view environment as an impediment to our mission. We must look for opportunities to develop and field "clean" technologies which meet our mission needs.

Cleaning Up the Mess

One of the reasons our hazardous waste cleanup situation is so backlogged today is because the cost of managing the hazardous waste stream was never factored into the cost of doing business. A recent Army study shows for every dollar spent to procure a hazardous material, $8 to $10 are required for handling and disposal! These costs have not been included in any budget, yet they represent the true cost of executing our mission. This is one reason we face huge cleanup costs at our bases slated for

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closure. Congressman Richard Ray of the House Armed Services Committee put it well when he said, "Next to outright conflict itself, this (base cleanup) is probably the No. 1 priority the Defense Department has to face."[4] Correcting the way we do business to prevent this situation from recurring should be one of the cornerstones of our strategy.

We must identify, track, and centrally control all hazardous materials from cradle to grave. We must automate and integrate the Federal Cataloging System and national stock numbers, mil-specs, and technical orders to identify and track current end uses. In 1982, an effort was started to develop a coding within the cataloging system to flag national stock numbers for the purpose of tracking radioactive items. Inability to agree on a suitable method of "flagging" the stock number and location within the catalog system brought the process to a standstill. This concept should be broadened to tie into a database for all materials deemed to be hazardous. This is a large undertaking and will require a substantial commitment of funds to make these changes to our logistics systems.

Another problem stems from the process for assigning stock numbers. Each number can represent a variety of compounds, all of which are suitable for one specific end purpose. Ordering activities have no way of knowing or controlling which compound they will receive. Some compounds may be hazardous and others may not. One example is a sealant used for aircraft fuel cells. One of the compounds qualified as meeting the stock number requirements contains lead peroxide, a hazardous material. Other compounds considered "equivalent" are safe. Because we have no way to exclude the lead peroxide vendors from bidding, we have become the dumping ground for vendors whose commercial market has changed to safe alternatives. Part of the solution to this involves enforcing and possibly revising Federal Standard 313 as well as revamping the stock number system so each stock number translates to one unique compound. Lack of an integrated system and inadequate focus on environmental impact create a situation in which the Air Force is rejecting environmentally safe technologies in favor of hazardous ones because we have no provision for discriminating.

Cradle to grave management also implies the need to track issuance, inventory, and disposal of hazardous materials. In the case of ozone depleting chemicals, failure to manage the inventory could result in weapon systems becoming nonoperational. The chemicals required to service our existing aircraft, missiles, and support equipment will be outlawed after the year 2000, and availability will dwindle during the intervening years. Since the United States signed a treaty with over 90 other countries agreeing to outlaw these chemicals, it is unlikely Congress will violate the treaty because the military failed to plan ahead.

Once we have identified all the weapon systems and procedures requiring hazardous materials, the plan should include provisions for evaluating potential alternatives. Where they exist, they should be programmed, funded, and implemented. Where they do not, Logistics Needs (LNs) should bring these requirements for technology solutions to the research community. In 1986, an Air Force Scientific Advisory Board report, "Selection and Use of Hazardous and Toxic Materials in the Weapons System Development and Acquisition Process," identified a need for management to address this issue. Additionally, the Environmental Research Strategic Plan should include bold research proposals to address current processes critical to defense which require hazardous materials.

Because many of our military industrial processes are like those used by the private sector, this approach to research is likely to produce transitional technology. Major system development programs, such as the Strategic Defense Initiative (SDI) and V-22 Osprey, have historically produced spinoff technologies of commercial interest. Why not environmental research too? This concept is consistent with Senator Nunn's comments concerning a change in direction for Defense researchers toward environmental work.[5]

Our strategy should also reinforce "conventional" environmental issues. These include indoor air quality, underground tank monitoring and replacement, hazardous material response system implementation, and tracking and correcting regulatory violation notices.

Minimizing Future Impact

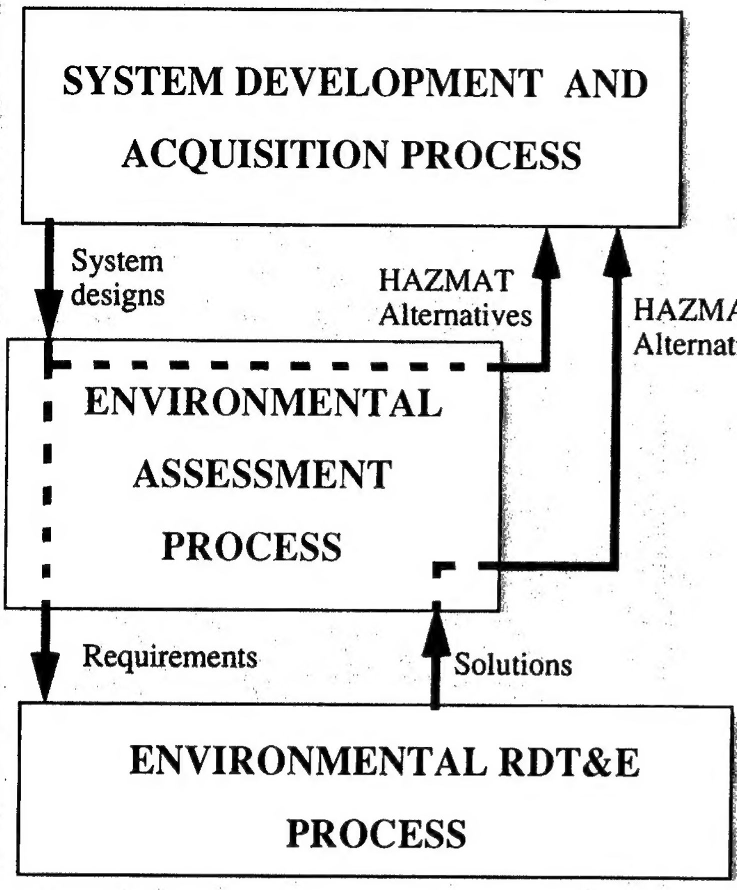
In the long term, the objective must be to avoid the need for hazardous materials wherever possible. This focus must begin at the conception of a new weapon system and remain until the system is retired from service. Only recently have we developed the technology and an understanding of our impact on the environment which enable us to implement such a program. A key design consideration should be the life cycle requirement for hazardous materials, to include development, manufacture, maintenance, operation, and disposal of a weapon system. This responsibility rests primarily with the Program Executive Officers (PEOs) and System Program Offices (SPOs). The Program Management Responsibility Transfer (PMRT) process should also highlight the hazardous materials management responsibility which goes with ownership of the system. Additionally, assessments of and justification for the use of hazardous materials should be mandatory and deliverable in all contracts.

Environmental, occupational health, and toxicological expertise must be used to conduct periodic independent assessments of the future supportability and environmental consequences of a proposed design. As the design progresses, assessments should include quantities and types of hazardous materials required to support the system through its life cycle. From this, the design team can produce estimates of the cost of handling and disposing of the material and the occupational health impact of various design choices. These assessments should be sent to the PEOs and SPOs to become an integral part of design decision process and to owning commands and the Air Force Logistics Command. These costs should become part of the budget line to accurately reflect ownership costs for the weapon system and provide resources necessary for its proper management.

Change in Perspective

Institutional impediments currently exist to such an approach to weapon system acquisition. In the short term, development and production belong to the development community. The long-term care, feeding, and disposal belongs to the logistics community. While the acquisition process is changing to address supportability issues, compartmented responsibility remains an obstacle to allowing life cycle concerns, including environmental ones, to affect design decisions. Preoccupation with performance needs to be tempered to include environmental performance as a consideration. A case in point is a recent $50 million major modification contract proposal to install a new overwing fairing fire protection system on the B-1B. The system

STRATEGY TO MAXIMIZE ENVIRONMENTAL PERFORMANCE OF NEW SYSTEMS



PROPOSED ADDITIONS TO ACQUISITION MILESTONE CRITERIA

1) Identify all hazardous materials required to support system.

2) Justify use of each chemical based on analysis of available alternatives.

3) Estimate quantities of each chemical needed throughout life cycle.

4) Estimate resources needed to manage resulting hazardous waste stream.

5) Include resource requirements in appropriate budgets of acquiring, maintaining and operating commands.

ENVIRONMENTAL ASSESSMENT TEAM

1) Independent of acquisition office (PEO, SPO, etc).

2) Interdisciplinary to include environment, safety and occupational health concerns.

3) Cleared at level necessary to allow full access to all design and other development information.

BENEFITS OF IMPLEMENTING STRATEGY

Decisions to use hazardous materials are justifiable based on analysis of requirements and evaluation of potential alternatives rather than relying on "we've always done it that way" approach.

Avoids future disposal problems because handling and disposal costs are part of budget.

The Environmental Research, Development, Test and Evaluation (RDT&E) program becomes tied to firm customer requirements for environmentally safe technologies which are generated by our systems acquisition community.

Provides clearinghouse for Air Force uses of hazardous materials and analysis of alternatives. Serves as quick means to assess impact of changing environmental regulations. Example: phaseout of chlorofluorocarbons (CFCs) and halons -- ozone layer depleting chemicals.

Institutionalizes a process for producing most environmentally benign systems possible, consistent with mission requirements.

BASIS FOR EVALUATING ALTERNATIVES

PERFORMANCE
SUPPORTABILITY
RELIABILITY
MAINTAINABILITY
AVAILABILITY
ENVIRONMENTAL FATE
COST
SAFETY
OCCUPATIONAL HEALTH
SEARCH FOR SIMILAR COMMERCIAL APPLICATIONS

requires the use of Halon 1301 firefighting gas, the most potent ozone depleting chemical in production today. Global production sources will cease to exist in the year 2000, and taxes will drive the cost from about $2 per pound today to over $65 per pound before production stops. The chemical was selected because it is the best performing firefighting agent. The weapon system designers and maintainers must understand the hazardous waste stream any new acquisition will produce. They must be prepared to justify the need for hazardous materials and be forthright about the costs, environmental impacts, and any possible future serviceability problems.

Implementing this program will require a commitment of Air Force resources necessary to support the goals of Secretary Cheney and General Viccellio. Appropriate corporate approval bodies such as facilities boards, panels, and the Program Review Committee should be at the forefront of converting environmental rhetoric into action. This commitment may increase cost and possibly delay some weapon system programs. This may be due to the need to design out some materials, to develop alternative technologies, and in some instances to initiate new programs to modify existing systems. The conventional approach is to let the logisticians focus on waste stream treatment. The new approach should be to require the acquisition community to reduce the stream as much as possible. To do otherwise is to exacerbate our future handling and disposal problems. With environmental standards becoming more stringent, not more lenient, this is not a wise approach.

Retaining International Leadership

Implementing such a program would improve our international image and further our foreign policy objectives. As our global environment gains more popular and political support, we have an opportunity to retain our close working relationship with other countries by demonstrating leadership on environmental issues. The NATO Committee on the Challenges of Modern Society (CCMS) offers one such opportunity.

Final Comments

The cost of doing business in a more environmentally responsible manner will not be cheap or easy, but we cannot afford not to. While military spending cuts are inevitable, a smart strategy for retaining as much as possible is to improve our environment. We should change our perspective and add environmental performance as a measure of overall weapon system performance. Our strategy must reflect an understanding of the fundamental link among responsible environmental stewardship, securing resources to meet mission requirements and accomplishing foreign policy objectives. We should present a thoughtful strategy for bringing these issues together throughout the planning and budgeting process. The time is right. Environmental concerns are persistent. They are not a passing fad. To retain our national role as a global leader and maintain our preeminence in airpower, we must demonstrate our commitment to the environment through deeds, not words.

Notes

[1]"U.S. Military Leaves Toxic Trail Overseas," *Los Angeles Times*, p. 1, 18 June 1990.

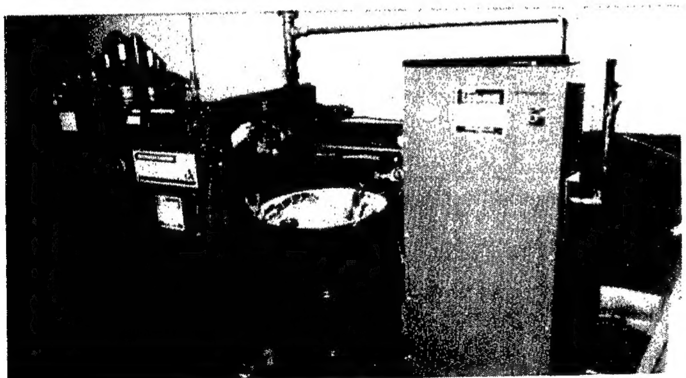
[2]"Senators Propose Shift of Defense Funds to Study Environment," *The Washington Post*, A7, 29 June 1990.

[3]"National Defense Authorization Act for Fiscal Year 1991," Press Release of Senate Committee on Armed Services, 13 July 1990.

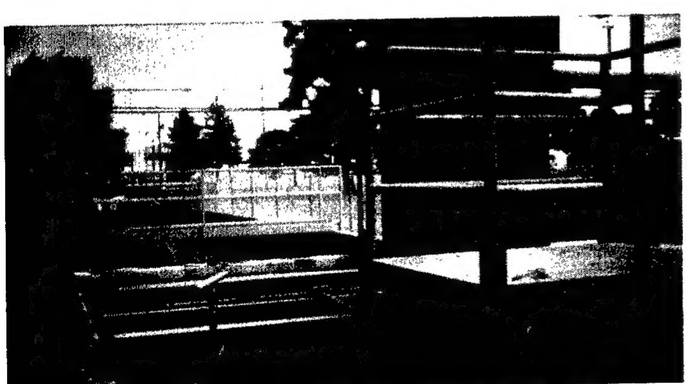
[4]"The Military's Toxic Legacy," *Newsweek*, 6 August 1990, p. 20.

[5]"Senators Propose Shift of Defense Funds to Study Environment."

MAKING PROGRESS



Solvent recycling still.



Oil/water skimmer and separator in storm sewer lines.

AIA Award

Major General Joseph A. Ahearn, Director of Engineering and Services, HQ USAF, Washington DC, was recently selected Honorary Member of the American Institute of Architects (AIA) in recognition of his outstanding contributions to the architectural profession and the allied arts and sciences.

To promote quality design for Air Force building projects, General Ahearn created the Board of Visitors, comprised of representatives from the design professions who advise his staff on ways of improving the natural and built environment of Air Force bases worldwide. The jurors wrote: "Through a lifetime of effort, General Ahearn has elevated the standards of design for Air Force facilities worldwide."

Termination of Federal Construction Contracts: Are Performance Bonds a Panacea or Panic?

Howard D. Standerfer
Contract Specialist
Rio Grande National Forest
Monte Vista, Colorado 81144

Introduction

The Federal Government has a rather pervasive right to pursue a termination for default and its attendant remedies. However, such action may not be in the best interests of the Government. The determination as to whether to pursue default termination is by no means cut and dried. It requires a thorough analysis of all factual data and available options, and the ultimate decision rests with the informed judgment of the Program Manager and Contracting Officer.[1] Very little has been previously published in one place regarding the procedure for using performance bonds in terminated Federal Construction Contracts. This paper attempts to rectify that situation.

Previous Research

A review of several studies on terminated Government contracts showed a reluctance to use termination for default as a viable alternative. For instance, a 1980 Defense Audit Service study found that contract terminations constituted less than 1% of the DOD procurement program. Of this 1%, the breakdown was approximately 60% termination for convenience and 40% for default. The study showed that financial problems caused the majority of the defaults.[2] This study also showed that only 7 of 59 default terminations were based on failure to make progress. On the surface, this statistic would not appear to be a bad average. However, one of the actions resulted from anticipatory repudiation, and the remaining six actions resulted from contractor bankruptcy. The contract files reflected no reliance on adverse indicators that surfaced prior to the actual repudiation or bankruptcy.[3] Of the 59 defaulted contracts studied by the Army, the following data were developed:

- 98% of defaulting contracts were firm-fixed price type.
- 78% were formally advertised, with the majority being "Small Business Restricted Advertising."
- 97% were considered to be small business.

The study's statistics on default reflected that over 50% of the small business defaults stemmed directly from financial problems.[4]

In another study, individuals frequently emphasized that management had little interest in performance management or default terminations due to a preoccupation with funds obligation. Some even went so far as to question whether management would support a Contracting Officer who initiated a termination for default. Whether or not such opinions are justified, they reflect a widespread perception at the working level.[5] This study went on to say, "exhortation," "jawboning," appeals to patriotism, and the like have only infrequently turned around a poor performer. Termination for default is always available in the case of nonperforming firms. However, because of limited sources of supply and delays in reprocurement, this option is used only as a last resort.[6]

The General Accounting Office (GAO) conducted a study of Federal Construction Contracting for nine federal construction agencies for FY72 with the following results: Total expenditures for direct federal construction in FY72 totaled $4.7 billion. The nine agencies studied accounted for about 63% ($2.95 billion) of the total direct federal construction expenditures for FY72.[7] For a 10-year period, the Corps of Engineers had 73 defaulted contracts with a total contract award value of about $30 million. During that 10-year period, the Corps awarded about 20,000 contracts valued at about $11.7 billion. The number of defaulted contracts represented less than 1/2 of 1% of total contract awards.[8] For the period 1963-1972, the Atomic Energy Commission (AEC), the National Aeronautics and Space Administration (NASA), and Health, Education and Welfare (HEW) were able to identify only five, two, and six defaults respectively.[9] This study did not, however, include payment bond claims.

On the other hand, of the 90,146 Small Business Administration (SBA) bond guaranteed jobs that were let from 1971 through the third quarter of FY79, records showed 5,551 jobs defaulted. That means approximately 94% of these jobs have resulted in success, while 6% were failures to one degree or another. Most of the reasons for failure, according to the SBA, were financial mismanagement.[10] Also, a great majority of the SBA payments were against payment bonds only.

Based on this research, I do not believe termination for default is being used as a working alternative for firm-fixed price Government contracts. Funding obligation problems, limited sources of resupply in some cases, and delays in reprocurement all argue against the termination option for an agency interested in assuring timely completion of a service or delivery of a product. In addition, attempting to get excess reprocurement costs out of a nonconstruction contractor already in financial trouble would be difficult to impossible. Irrespective of the foregoing problems, however, the right of the Government to terminate for default may be forfeited if a Contracting Officer fails to recognize available indicators of performance difficulties and to respond to these indicators in a timely and effective manner.[11]

With regard to firm-fixed price federal construction contracts exceeding $25 thousand, the Contracting Officer should have more flexibility in considering termination for default since such contracts require a performance bond in the amount of 100% of the contract price.[12] In these cases, a surety remains liable to the Federal Government for all amounts required to complete the project up to the penal sum stated in the performance bond.

Reluctance to Terminate Construction Contract Backed by Surety Bond

Some of the reasons that Program Managers do not wish to terminate a contract for default have been discussed earlier in this article. However, the reasons for reluctance to terminate a

construction contract backed by a surety bond fall into three main categories:

(1) Reluctance to delay completion of the job.

(2) Reluctance to reallocate or locate additional money to complete the contract.

(3) Fear of wrongful default.

The remainder of this article will show that it is the duty of Government Contracting Officers to advise Program Managers of the options available to them so together they can make fully informed and intelligent decisions regarding default termination of a construction contract that has a surety bond. It will also allay some of the fears that both parties may have when stepping into a termination for default abyss.

Background

Until 1983, the termination decision was fairly simple—termination was not a viable option unless the contractor had repudiated the contract or gone bankrupt. This was true because, until 1983, the Comptroller General held that excess costs which a contracting agency recovered from a defaulted contractor (1) had to be deposited in the Treasury as miscellaneous receipts, and (2) the money received from the surety could not be used to reimburse the appropriation which financed the particular project and then be applied to a reprocurement contract for completion of the work. Therefore, if the surety wanted to pay the penal sum of the bond, rather than completing the work, the rule forced the agency to choose between foregoing completion of the defaulted project or going back and asking Congress for a supplemental appropriation to complete the defaulted project.[13] However, the Comptroller General in Decision B-210160 reversed this rule:

> We do not think it is logical to insist that a breaching contractor is legally responsible for excess reprocurement costs and then, when the contractor fulfills that obligation, refuse to permit his payments to be used for that purpose. We regard the contractor's payments as being analogous to a contribution to a Government trust account, earmarked for a specific purpose. Just as the proceeds of a trust are considered to be appropriated for the purpose for which the funds were deposited, so too should excess reprocurement collections be considered to be available only for the purpose of funding a replacement contract.
>
> We therefore decide that to the extent necessary to cover the full costs of a replacement contract, excess reprocurement costs recovered by an agency from a breaching contractor (or his surety) need not be deposited in the Treasury as miscellaneous receipts. The replacement contract must be coexistive with the original contract; that is, it may procure only those goods or services which would have been provided under the breached contract[14]

This decision, unfortunately, still does not pull the Contracting Officer or the Program Manager out of the funding dilemma. As will be discussed later, the Contracting Officer cannot ask for the excess reprocurement costs from the defaulted contractor or the surety until the reprocurement contract is complete and a final payment is made to the successor contractor.

Procedures Prior to Termination

The actions taken by the Contracting Officer prior to termination are critical in determining what recommendation to make regarding termination as well as what position the Government will be in with regard to recoupment of excess reprocurement costs.

When contractors begin to find themselves in difficulty, the shell game begins usually by a frantic attempt to cover their operating deficiencies by accelerating cash flow. Often, with contractors about to go down the tube, the problem is discovered to have originated, not with the current job which finally sounded the alarm, but with a whole series of past projects whose finances have become intertwined and finally threaten to bring down the company. The prospects for recovery at this point are not good. The president of a large consulting firm who works with bonding companies has stated that only 15% of the contractors who find themselves in this situation survive.[15] If allowed, agencies should request information on the contractors' previous jobs and coordinate with the Contracting Officers and inspectors on those jobs to provide a view into current and past performance of the contractors prior to award. An old adage goes that, "An ounce of prevention is worth a pound of cure," and that is very true in this case. But, what if the contractors' numbers looked good and they were awarded the contract anyway?

One of the first indicators that things are not going well is nonpayment of bills to suppliers or subcontractors. If contractors are not paying their bills, it is a good idea for Contracting Officers to notify the sureties as soon as they are aware of the problem. The sureties may then have the opportunity of seeing that subcontractors and critical suppliers are paid before lack of payment causes them to leave the job or slow down, if not totally interrupt, progress on the project.[16] Of course, as with all the indicators to be discussed, it is vital that Contracting Officers have an open line of communication with the field inspectors because they will be the first to be aware of the indicators. Contracting Officers need to know what is going on out in the field as quickly as possible to protect the Government. A 1980 US Army Procurement Research Office Study identified other performance indicators which would flag problems with the awarded contract, such as milestone slippage, lack of physical progress, technical difficulties, and financial problems.[17] When contractors are in trouble and they are either unwilling or unable to progress with the job in a timely fashion or to complete it at all, the sureties should be invited to all meetings with the contractors. All communication with the sureties should be in writing so it will be clear what information was made available to the sureties, when, and by whom.[18]

If a surety is aware of a problem, it is not unusual for the surety to loan funds to its contractors to permit them to complete the project rather than incurring the additional expense of finding a new contractor to complete the job at inflated prices. However, one of the dangers to the surety in undertaking the financing option is that it does not reduce its liability to the owner by financing the contractor.[19]

While the original contractor is still performing the contract, the Contracting Officer must carefully consider any material deviation requested by the contractor to increase cash flow, not only for the reasons mentioned previously, but also because, if there is any material deviation from the contract without the surety's advance consent, the surety is likely to claim that the contract conditions have been modified without its consent, resulting in discharge from liability.[20] While most performance bonds provide for modifications to the contract without further consent of the surety, the issue sometimes arises as to whether the modifications are within the scope of the contract or are covered by the advance consent clause.

Another danger of surety discharge facing the owner is that of overpayment or underpayment of the contractor, or payment for work improperly performed. A contract generally provides that the owner will pay the contractor on a monthly basis for a percentage of the work properly performed and materials suitably stored at the job site or at some other agreed location. A material departure from such payment requirements operates

to discharge the surety from liability.[21] While it is doubtful that any contractor has ever complained of receiving an overpayment or of receiving payment for work improperly performed, the surety may once again claim that such payments have prejudiced its rights by depleting the contract funds that would otherwise be available in completing the project. If payment has already been made, it will be necessary to search for ways to justify the payment in view of the contract requirements. To the extent that the facts will support it, the owner should show that the payment was made in reliance upon the contractor's certification that it was due and without actual knowledge to the contrary. The surety is not discharged by the misrepresentations of its own contractor.[22]

Fortunately for Contracting Officers, in most instances, courts refuse to find the surety discharged unless the change is substantial. Even in those instances where discharge is held, courts almost universally maintain that the discharge of the surety is only to the extent of the prejudice and not total.[23]

The Decision to Terminate

When a requirement still exists for the item under contract, the following considerations may be relevant: (1) the nature and seriousness of default, (2) the availability of other sources to satisfy the requirement, (3) the urgency of the procurement, and (4) the ability of other available sources to produce the item before the contractor can make delivery.[24]

Also, another consideration of a decision to terminate a contractor for default is that, if a contractor is expected to default, the Government has a heavy burden of proof in an anticipated default. While there is some evidence of a relaxed standard, the burden of proof is still clearly on the Government. Due to the general reliance on exception management, the Contracting Officer is often unable to compile or analyze factual data required to support an Expectant Default termination in a systematic manner.[25] Although it is not the subject of this article, the Contracting Officer contemplating an anticipated default should proceed with caution and have sufficient evidence available to support that position if necessary.

With regard to the funding of a potential reprocurement contract, the Boards of Contract Appeals have held that a reprocurment contract must have been completely performed and full payment made to the reprocurement contractor before the Government can recover reprocurement costs from a defaulted contractor or its surety.[26] Therefore, the agency is faced with the need to locate a source of money to pay the reprocurement contractor who will complete the defaulted job as well as determine the ability of the defaulted contractor, or secondarily, the contractor's surety to make good on a demand from the agency for excess reprocurement costs that will be made in the indeterminate future.

There are sources of funds available to complete the project from other than current operating funds or asking for additional appropriations. For instance, in 1981, the Comptroller General held that, when a contract is terminated for default, any amount obligated to fund the original contract remains available to fund a replacement contract. In the same decision, the Comptroller General held that with regard to reprocurement costs in excess of the remainder available in the original contract, the agency could use unobligated funds, if any, from its prior year appropriations to increase the amount of obligations chargeable in the year that the original contract was let to pay the replacement contractor the full amount owed.[27]

If there are no prior year unobligated funds available and demand for excess reprocurement costs cannot be made on the defaulted contractor or the contractor's surety until after the work is done, the agency is placed in a position where it must go deficit in its currently appropriated funds or ask for additional funds prior to letting a reprocurement contract. This drawback, more than any other single factor, prevents the termination for default tool from being effective. However, a proposed solution out of this dilemma will be discussed later in this article.

Also, prior to a decision on termination, the financial health of both the potentially defaulting contractor and the contractor's corporate surety must be determined. As previously mentioned, the major reason for a contractor's default is financial difficulty. As was also mentioned, only 15% of contractors who are terminated due to financial difficulties ever survive the termination; therefore, the opportunity of recouping reprocurement costs from a defaulted contractor appears slim. In fact, in FY79 a DOD study on contracts showed an actual reprocurement cost collection rate of less than 1% of the reprocurement costs assessed. The study also determined that the low collection rate was due to the fact that most defaulted contractors were insolvent.[28] At one time, if the contractor was backed by an individual surety, the chances of recoupment of excess reprocurement costs were low, as it was the Contracting Officer's responsibility to determine the adequacy of the individual surety's assets. Usually, the Contracting Officer had neither the time nor the expertise to make such a determination. Recently, however, a revised, proposed rule has been published in the Federal Register placing the responsibility back on the contractors to prove the adequacy of the assets of the individual sureties.[29] If this proposed rule is used, the chances of collecting against an individual surety are greatly increased.

If the surety is a corporate surety, the next step for the Contracting Officer is to investigate the financial solvency of the surety. All sureties approved to issue bonds on Federal Government Contracts are listed on Treasury Department Circular 570. The circular is updated by adding and deleting authorized sureties via the Federal Register. The Contracting Officer should ensure that the surety is still on the list as the Treasury Department dropped 29 firms from the list of about 400 firms from July 1985 to January 1987.[30] In order for a corporate surety to be placed on the TD Circular 570, the Financial Service of the Department of the Treasury (DOT) does a financial analysis of an unaudited year-end financial statement provided by the company. Also, the DOT only allows a bonding company to commit 10% of its net worth to covering government bonds.[31] A call to the Financial Service Division can also provide the Contracting Officer with additional information about the surety (net worth, certain financial ratios, and if it is a subsidiary of a larger, more solvent company).

A phone call to Dunn and Bradstreet or other commercial business credit reporting agency could provide valuable insights into the present solvency and future prosperity of the company. Another source of information is Best's Insurance Reports. State and local contracting agencies are taking a closer look at the financial health of the bonding companies their contractors use. For example, Harris County, Texas, will not approve performance or other bonds from sureties with ratings of less than A– in Best's Insurance Reports.[32]

Another source of funds is provided if the bond is an SBA-backed bond. Although the Contracting Officer must request payment of excess reprocurement costs from the defaulted contractor first and the surety second, there may be an occasion when both the defaulted contractor and the surety are

bankrupt. In this case, if the bond is an SBA-backed bond and if both the contractor and the surety have become insolvent and the bond is an SBA-backed bond, the agency must go to the state department of insurance where the surety was located to file a claim. When the state department of insurance pays all or a portion of a claim, they can go to the SBA in Washington DC and recover that portion of the bond that was guaranteed by the SBA. In past years, the law had set the SBA bond guarantee at 90% of the bond penalty. Recently, it has been set administratively at 80%.[33] It should remain at the 80% level for awhile.

The program manager should not be reluctant to declare default on a contractor because of delay in the completion of the project, as the Contracting Officer has been given wide discretion to select a reprocurement contractor and let the reprocurement contract in an expeditious manner. For instance, the Government is not barred from using its own forces to satisfy its requirements after a default. Nevertheless, unless it justifies that action, it may not complete the work with its own employees at a higher cost than available elsewhere (Brent L. Selick, ASBCA 21869).[34]

If Contracting Officers decide to let a reprocurement contract, they may use competitive bidding or negotiation, whichever they deem to be in the best interests of the Government. Contracting Officers are not required to arbitrarily accept the lowest offer received. They may consider time of delivery and qualifications and capacity of the bidder. However, they must not abuse this discretion and must use diligence to obtain the lowest price available.[35] However, if Contracting Officers do not accept the lowest price, they must be able to demonstrate that some negotiation and price analysis took place and reasonable competition was obtained (Century Tool Co., Inc., GSBCA No. 4000, 76-1 BCA Sect 11,855), although sole source procurement will be permitted if required by the circumstances (Consolidated Airborne Systems, Inc.).[36]

When in doubt, it is advisable not to declare the contractor in default until the situation clearly demands it; but once this becomes unavoidable, it is important to the job and, ultimately, to contractors and their sureties, that owners move forward promptly with the default declaration and formal demand upon the surety. Once the contractor has been properly declared in default, the surety's performance bond obligations are normally triggered.[37]

Procedures After Termination

The sureties' liability on the bond gives them certain rights in the event the contractors should default—if the sureties wish to complete the work themselves, they should be permitted to do so. In this case there may be a "takeover" agreement between the sureties and the Government. Specifically, the Government agrees to recognize the sureties' right to receive payments out of amounts withheld from the contractors. The sureties' rights are limited, however, as they may be paid only the costs of completing the work. And in no case may this amount exceed the unpaid balance of the contract price at the time of default.[38] However, if the sureties elect to have the Government procure the services needed to complete the contract, the burden is on the Government to prove the propriety of excess reprocurement costs. The various boards of contract appeals have held the Government has to make at least a *prima facie* showing it has met the following constraints:

(1) The reprocurement was made within a reasonable time (after the termination).

(2) The reprocurement price was reasonable.

(3) The Government endeavored to mitigate its damages.

(4) The reprocurement contract was performed.

(5) Payment was made to the reprocurement contractor.

(6) The Government must reprocure substantially the same services as those called for under the defaulted contract, and the terms and conditions of the reprocurement contract may not vary materially from those of the defaulted contract.

(7) Requirement for the Government to notify the surety of the termination of the contract at the time of termination.

Failure to comply with any of these constraints could relieve the surety and the contractor from having to pay excess reprocurement costs.

With the exception of items (4) and (5), which are basically self-explanatory and discussed previously in this paper, a rather substantial body of law has developed regarding the interpretation of these items. Perhaps the most complete discussion of the legal interpretation of these constraints can be found in the Cibinic and Nash book, *Administration of Government Contracts*, 1981 edition. A good source for ongoing development of interpretation of these constraints is the "Government Contractor" loose-leaf service published by Federal Publications, Inc.; or, for those who are really modern, and have the funds, a subscription to *WESTLAW*, *LEXIS*, or other legal on-line research service might be appropriate.

Besides being liable for the difference between the amount of funds available on the defaulted contract and the cost of the reprocurement contract, the surety's liability under a performance bond can entail a wide variety of damages. In line with the general rule that a surety's obligations are generally measured by those of its contractor, sureties have been held liable for not only the increased cost of completion of a project, but also for other consequential damages, such as rent paid on another building while awaiting occupancy, lost profits which the building would have generated, loss of use, and rental costs. Sureties, in some cases, have also been held liable for other delay damages, such as maintenance expenses on the job site, salaries for watchmen, a proportionate share of the expenses of the owner's main office, and other fixed overhead expenses. In each instance, the expressed or implied goal of the court in awarding these damages is to place the aggrieved party in as good a position as it would have been but for the breach of the principal's contract.[39]

The GAO reviewed 75 defaulted contracts involving 9 federal construction agencies. In only three cases, involving the field offices of two agencies, were attempts made to obtain reimbursement from contractors or their sureties for administrative costs. In one case, an agency's field office estimated it had incurred administrative expenses of about $3,200 in awarding a completion contract for a defaulted project. The surety reimbursed the agency for the claim. Based on the results of this study, the GAO came to the conclusion that any additional administrative costs incurred by a federal agency as a result of a default qualify as a financial loss protected by a performance bond and that federal construction agencies should seek reimbursement from sureties for such administrative costs.[40]

After the reprocurement contract is completed and final payment has been made to the reprocurement contractor, a bill for reprocurement costs should be issued to the defaulted contractor within 30 days. If the defaulted contractor does not respond, or if the defaulted contractor is no longer in business, demand should be made on the surety for payment in 30 days. If the defaulted contractor is bankrupt, the defaulted contractor

should be bypassed and original demand for payment should be made on the surety. A surety must promptly honor its bond obligation; however, one additional notice to the surety should be sent if there is no response after the first notice has been out for 30 days. If the surety fails to respond after the second notice, legal counsel should be notified so that legal avenues of recourse can be pursued. Also, the US Forest Service has established procedures so that, if a surety does not pay or respond with a defense as to why it should not pay, the agency can request the Secretary of the Treasury to revoke the surety's certificate of authority to underwrite Government bonds.[41]

Recommended Changes in the System

A US Army review of 21 defaulted contracts noted that the absence of specific guidance concerning excess reprocurement costs resulted in inconsistent application, token assessments, and quite often no assessments. Furthermore, when consideration was recovered, only the most obvious and easily measured costs were included. Other costs, including those costs for administration, excess correspondence, lost productivity of personnel, and equipment downtime were not considered.[42]

The Defense Acquisition Regulatory Council (DARC) and Civilian Agency Acquisition Council (CAAC) should amend the Federal Acquisition Regulation (FAR) to include a list of cost items that can be considered when determining excess reprocurement costs. A statement should be included saying that the list is not all inclusive and that every item on the list may not be a cost item on every contract.

The Contracting Officer, as the business manager for the agency, should have the lead in recommending termination for default. The regulations should be changed on a prospective default situation to allow the Contracting Officer to do a risk analysis and then to be able to present it to the Program Manager for approval. Currently, the Program Manager must initiate the termination for default action and may be fearful of doing so due to the twin specters of completion delay and lack of funding. The US Air Force procedure can serve as a useful example. The Air Force form required to be prepared for terminations must be initiated and approved by the Program Manager or the user of the service or supply before it goes to the Contracting Officer. In addition, depending on local Air Force rules, there can be up to five coordinating signatures for which room is provided on the form.[43]

Because current funds are not always immediately available to pay for excess costs on reprocurement contracts, I would recommend that an industrial fund be established for use by all Federal Agencies when entering into reprocurement contracts. The agencies could take from the fund as necessary when reprocuring and replenish the fund when the reprocurement costs are acquired from the defaulted contractor or surety. An industrial fund is a revolving type fund established to provide working capital for the operation of industrial-type or commercial-type activities. Under industrial fund operations, cash and inventories represent capital and thus make operation of the activity on a basis comparable to private business.[44]

Each industrial-commercial activity is provided with a single revolving fund or project cash account with which to buy materials, supplies, labor, and other services needed in the rendering of the service. The fund or project cash account is reimbursed on the basis of the cost of the goods delivered or the services rendered to customer activities out of funds appropriated for the operation of these customer (consumer) activities. This type of management simplifies the financial structure of the industrial-commercial activity and encourages the exercise of business-type controls in its management.[45]

Finally, default terminations are relatively isolated events, so there is a tendency to not be familiar with proper procedures. Knittle and Carr recommended that Chapter II of a 1980 study they did for the US Army Procurement Research Office be widely distributed to provide a ready reference on basic doctrines and procedures for default terminations.[46]

Conclusion

A default termination on a Federal Construction Contract that has a solvent surety is a viable alternative to consider if the present contractor is in financial difficulty and the Government can prove expectant default and specified procedures are followed. If the recommended changes listed are enacted, agency internal procedures regarding termination for default could be relaxed and troubled contractors could be placed on notice that failing to comply with the contract provisions could result in a termination for default.

Notes

[1]Knittle, Duane D., and Carr, Dariel M. "Detection and Avoidance of Contractor Defaults" (Research Paper, U.S. Army Procurement Research Office, Ft. Lee, VA, 1980), p. 3.

[2]McNulty, John Q. "The Nature and Extent of Current DOD Contractor Default" (Research Paper, Florida Institute of Technology, Ft. Lee, VA, 1984), p. 11.

[3]Knittle and Carr, "Detection and Avoidance of Contractor Defaults," p. 99.

[4]McNulty, "The Nature and Extent of Current DOD Contractor Default," pp. 13-14.

[5]Knittle and Carr, "Detection and Avoidance of Contractor Defaults," p. 107.

[6]McNulty, "The Nature and Extent of Current DOD Contractor Default," p. 18.

[7]U.S. General Accounting Office. *Use of Surety Bonds in Federal Construction Should be Improved*, Report No. LCD-74-319 (Washington DC: Government Printing Office, January 17, 1975), p. 5.

[8]Ibid., p. 18.

[9]Ibid., p. 18.

[10]U.S. Congress, House, Committee on Government Operations, Hearing before a Subcommittee of the House Committee on Government Operations on the Effects of Bonding Requirements for Construction Funded or Insured by HUD, 96th Congress, 1st Session, Ser. 48-087 0 (Government Printing Office: Washington DC, 1979), pp. 37-41.

[11]McNulty, "The Nature and Extent of Current DOD Contractor Default," p. 10.

[12]FAR 28.102-1.

[13]The Government Contractor, Vol. 26, No. 4, Sect. 51.

[14]Matter of Bureau of Prisons-Disposition of Funds Paid in Settlement of Breach of Contract Action, B-210160, September 28, 1983, 62 Comp Gen 678.

[15]Ancipink, Patricia. "Inflation Squeezes Construction and Surety," *Best's Review*, October 1981, p. 36.

[16]Hinchey, John W. "Payment and Performance Bond Coverages and Claims," *The Arbitration Journal*, June 1986, p. 31.

[17]McNulty, "The Nature and Extent of Current DOD Contractor Default," p. 12.

[18]Hinchey, "Payment and Performance Bond Coverages and Claims," p. 31.

[19]Ibid., p. 27.

[20]Ibid., p. 27.

[21]Ibid., p. 28.

[22]Ibid., p. 30.

[23]Ibid., p. 29.

[24]Department of the Air Force. *Contract Administration*, 4th Ed., Air Force Institute of Technology: Wright-Patterson AFB OH, 1979, p. 119.

[25]Knittle and Carr, "Detection and Avoidance of Contractor Defaults," p. 99.

[26]Delphi Industries, Inc. AGBCA No. 76-160-4A and B, 83-2 BCA 17,053 (1976).

[27]60 Comp. Gen. 591 (1981) B-198074, Matter of Funding Replacement - Contracts, July 15, 1981, cited in Comptroller General Decision B-210160, September 28, 1983, 62 Comp Gen 678.

[28]Defense Audit Service, *Report on the Review of Contract Terminations*, Report No. 81-019 (Arlington, VA: Mimeograph, November 14, 1980), p. 3.

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Engineering and Services Logistics in Regional Warfighting Operations

Events in the Middle East in support of OPERATION DESERT STORM have created a need for unique logistics items and for acceleration of programmed equipment, vehicles, and supplies. In order to meet this need, Headquarters, Air Force Engineering and Services Center (HQ AFESC) has created a Vehicle, Equipment, and Supply (VES) Cell as part of the Operations Planning Division. This cell is staffed with a nucleus of dedicated full-time experts in vehicle, equipment, and supply issues covering engineering, fire protection, services, and logistics. Secondary team members, other than AFESC resources, augment the VES Cell to provide logistical details down to the line item manager level. The cell responds to immediate, short-term, near-term, and long-term requirements as requested by USCENTAF/DE, TAC Battle Staff/DE, and deployed units. The cell is working the acquisition of several engineering and services items, such as self-help laundries, rapid runway repair (RRR) vehicles and equipment, folded fiberglass mat systems, spall repair material, ice machines, audiovisual equipment to support training packages, and even security of computers and fax machines. (Capt Bill Greenough, HQ AFESC/DEOP, AUTOVON 523-6120)

Whole Neighborhood Program

The Whole Neighborhood Program is a comprehensive revitalization program which considers all community related issues for the entire housing community at each base. The actual development of the "Whole Neighborhood Concept" is in progress now through the development of Housing Community Plans (HCPs). These plans will evaluate existing conditions of military family housing (MFH), validate the total housing and neighborhood requirements, and provide a comprehensive programming and implementation plan for all future MFH revitalization projects. Once completed, the HCPs will provide for the orderly economical implementation of all proposed improvements through the use of a phasing plan that recognizes the priorities of the Air Force, the variable nature of funding for improvement projects, and the logical "sequence of construction" that must be followed in any project. (Mr Roberto Castellanos, AF/LEEHT, AUTOVON 227-0157)

Civil Engineering Materiel Acquisition System

Civil Engineering Materiel Acquisition System (CEMAS) is an inventory management program that was conceived by logistics personnel assigned to the AF Engineering and Services Center (AFESC) in the early 1980s. Its purpose was to improve logistics support to the Base Civil Engineer, integrating logistics processes such as the automatic reordering programs (a modified version of the standard base supply system (SBSS) aggregate model) and inventory controls, while maintaining prudent accountability. CEMAS was prototyped at Tinker AFB, Oklahoma, in May 1983 and became a "live" subsystem of the Work Information Management System in the fall of 1984. Over the past several years, program changes have taken place to ensure an even more responsive, user-friendly system. During 1989, HQ AFESC and Headquarters Standard Systems Center developed automatic inventory programs and also updated the management summary to provide extrapolation of the most significant data a logistics manager would need in the operation of their account. System enhancements will continue as changes at DOD and AF levels are mandated, or if we can improve any of the existing logistics processes. As of 1 November 1990, 91 of a possible 113 candidate bases have implemented CEMAS. CEMAS is also being implemented at each of the five Civil Engineering Maintenance, Inspection, Repair, and Training regions. We anticipate all CEMAS implementations will be completed by July 1993, with hardware acquisition being the major limitation. (CMSgt Curt Hines, HQ AFESC/DEMG, AUTOVON 523-6245)

Combat Air Base Performance Planning

Combat Air Base Performance Planning is a nontraditional approach to base development planning which postulates that the functional relationships and facility requirements can be combined through a process of deliberate planning which can greatly enhance and, in effect, provide an integrating activity for base and weapon system operations. Performance planning is nontraditional because it has operations as its focus, not the limited concern of physical layout.

To fully appreciate the value of performance oriented planning, one must dismiss the notions of city or campus planning that conceptually guide base planning today and accept a set of planning principles that have been proven over time to be a new and viable framework for planning.

Traditional base development planning differs from performance planning. The objective of performance planning is the satisfaction of related measures of merit with respect to operational missions. Thus, sets of planning principles and related measures of merit comprise the key elements of performance planning and are coupled with a process which considers planning data such as mission, environment, and threat to yield operationally enhanced base layouts. (Lt Col John Mogge, HQ AFESC/DEOP, AUTOVON 523-6121)

Engineer Role in Nation Building

The Directorate of Engineering and Services (HQ USAF/LEE) through the Directorate of Readiness (HQ AFESC/DEO) is working with USSOUTHCOM, US Army Corps of Engineers, and the Army-Air Force Center for Low Intensity Conflict to develop an umbrella program that employs Air Force engineers in nation-building missions tied to the development of Central and South American countries. From an engineering standpoint, nation building translates to creating an infrastructure such as roads, bridges, and airfields; training indigenous personnel in modern construction techniques; and providing technical guidance in the form of design and planning assistance, airfield surveys, and pavements evaluations. Many nation building initiatives have been completed, are underway, or are programmed for future accomplishment. These efforts directly support our nation's security strategy in that region and, furthermore, offer valuable insight, experience, and knowledge that could prove vital to providing future basing or airfield access if needed. (Capt Ibanez, HQ AFESC/DEOP, AUTOVON 523-6131)

New RED HORSE Concept for the 1990s

RED HORSE units are self-sufficient and independent engineering organizations for large-scale heavy repair projects. These units gained prominence during the Vietnam War with the construction of Tuy Hoa and Phu Cat air bases. Base closures overseas have signaled a departure from a forward defense posture to one of rapid force projection. Accordingly, HQ USAF/LEE is reviewing proposals to transition RED HORSE units to smaller, more deployable entities capable of executing warfighting and nation-building missions of the future. The future concept delivers three distinct echelons: 60-person team designed for light repair duties associated with nation building and natural disasters; 90-person team to provide air base planning assistance and technical support and site reactivations in contingencies; and 120-person team able to conduct bare base construction and major equipment maintenance and training. The new approach ensures large-scale civil engineering support is available to meet our force project requirements. (Chief Walton, HQ AFESC/DEOP, AUTOVON 523-6139)

New Self-Help Laundry

A new laundry system has been developed and tested for Air Force use in a bare base environment to allow individuals the opportunity to wash their own laundry if so desired. The laundry facility is designed to accommodate personal laundry, 27 pounds per person, per week, for 1100 people. Each facility contains three industrial-style washer/extractors, six home-style dryers, folding tables, and support equipment to include a 3000-gallon water bladder and 20-gallon-per-minute water pump. The equipment is housed in a 20- by 32-foot TEMPER tent and is supported by either Harvest Falcon or Eagle water and electrical distribution systems. Seven of these facilities have been shipped to DESERT STORM. (Mr Kalivoda, HQ AFESC/DEOP, AUTOVON 523-6160)

Engineering Runway Repair

Civil engineering's ability to repair bomb-damaged runways in a timely fashion is a prerequisite to launching aircraft after an attack. This difficult task just got easier with the initial fielding of a new folded fiberglass mat system. The new FOD cover, which is placed over a repaired crater, has undergone extensive testing during its developmental phase. Its purpose is to provide a better alternative to AM-2 aluminum matting, which has operational limitations, and concrete slabs, which are manpower and equipment intensive. The 54- by 60-foot folded fiberglass mat includes two sections consisting of nine pliable hinged panels. These two sections are bolted together with a splice panel. Due to its low profile, this FOD cover falls within flush repair criteria and lessens the aircraft bounce on impact. A successful initial operational test and evaluation (IOT&E) validated the mat construction characteristics, installation procedures, aircraft operability, and technical order. Full-scale production is underway with initial assets already deployed in support of OPERATION DESERT STORM. This new FOD cover is being integrated into worldwide Air Force rapid runway repair programs. (CMSgt David Bolin, HQ AFESC/DEOP, AUTOVON 523-6134)

Integrating E&S Forces into the Air Force CORE UTC

The CORE Unit Type Code (UTC) Package, an Air Staff Combat Support Task Force (CSTF) initiative, will improve the overall Air Force combat capability by delivering essential combat, combat support, and combat service support forces together under one umbrella for the projection of air power. The primary goal of the CORE UTC concept is to improve the Air Force's capability to rapidly deploy and commence effective combat operations with the minimum loss of combat efficiency. For Engineering and Services (E&S) forces, this means providing a deterrent force of 100 engineers, 24 fire fighters, and 25 services people that will deploy with each independent tactical flying squadron to provide it with the organic capability to bed down and feed its forces and to provide crash rescue and fire protection for the airplanes. Along with this "lean and mean" concept are dependent, destination-unique, and round-out UTCs that can provide additional personnel and equipment if they are needed for extended contingencies or war. (Mr J. H. Smith/DEOP, AUTOVON 523-6128)

Safety Modifications

The criteria for safety modifications have been revised and are in the process of being staffed and incorporated into AFR 57-4.

a. CRITERIA FOR SAFETY MODS: To be deemed a safety mod, it must meet all of the following criteria:

(1) The deficiency which the mod corrects must have caused or could cause loss or serious injury to personnel or loss or extensive damage to equipment.

(2) With the coordination of the Air Force Inspection and Safety Center (AFISC), and the System Program Office (SPO) at AFSC or the System Program Manager (SPM) at AFLC, the MAJCOM/CC will identify within 90 days of the mishap (as a part of the command endorsement per AFR 127-4, *Investigating and Reporting US Air Force Mishaps*) that it is a priority safety mod.

(3) The SPM or SPO grounds or places restrictions on the aircraft or equipment, or the MAJCOM/CC restricts training or operations until the modification is complete. These restrictions could take the form of dramatically increased inspection requirements to assess known durability/reliability problems which, if undetected, could result in catastrophic failure. Modifications which do not meet this criteria may be considered a safety mod on an exception basis if AFISC, the MAJCOM/CC, and the SPO or SPM agree to the safety implications. HQ USAF/LE/XO and SAF/AQ will be notified in advance of any proposed exceptions.

(4) The MAJCOM commander agrees to make aircraft or equipment available for all safety modification schedules.

b. POLICY CONCERNING TIMELINESS OF SAFETY MODS: All safety mods will be accomplished in the minimum amount of time required to ensure a safe and operationally effective fix. The following guidelines apply:

(1) All safety modifications will be tracked from the time the MAJCOM/CC approves the safety board report until all affected aircraft or equipment is fixed.

(2) The goal for accomplishing the engineering, test, production, and complete installation of the mod on the fleet or equipment is 18 months.

(3) The SPM or SPO will provide the MAJCOMs, AFISC, and HQ USAF/LEY/LEX/XOO a modification program management plan (MPMP) at the beginning of the program. The SPO or SPM will also provide a monthly status report on the progress of the safety mod. Message format is authorized. (Marge Larson, AF/LEYM, AUTOVON 227-5158)

The Air Force Logistics Assessment Architecture

Lieutenant Colonel (Col Sel) Douglas Blazer, USAF
Chief, Program Integration and Analysis Division
Directorate of Logistics Programs (HQ USAF/LEXI)
DCS/Logistics and Engineering
Washington DC 20330-5000

Donald L. Zimmerman
Senior Analyst
Synergy, Inc.
Washington DC 20330

TIME: *Today, BLA2 (Before the Logistics Assessment Architecture).*

BACKGROUND: *The United States has been monitoring rising tensions over the last several months in a Third World country, Orangeland. Suddenly, the radical forces in the country have overthrown the democratic government and have stormed the US Embassy, capturing 46 US citizens and holding them hostage. The United States must consider military options, including use of Air Force units. A close-hold planning team is put in place.*

THE SETTING: *A conversation between the senior logistics officer (General Log) and his Exec on planning the logistics support of the operation.*

Gen Log: *"The Ops and Intell wienies are planning this mission and the Air Force needs to provide a coordinated position to the Joint Staff on our recommended course of action to respond to the Orangeland situation. Can we offer Ops some proactive options based on our resource picture, or do we have to wait until the eleventh hour when we will get one hour to evaluate the logistics supportability of whatever schemes they come up with? What can you tell me ahead of time about our capability? I don't trust analysts or computers any further than I can throw them, but don't we have some kind of Gee Whiz models or systems or tools to help figure this out? We need a consistent assessment of our capability."*

Lt Col Exec: *"Yessir! I don't usually associate with analysts either, but I think we have something. I'll get back to you right away."*

(Lt Col Exec returns in a couple of hours to report to General Log.)

Lt Col Exec: *"Sir, I have talked to the assessment community about this situation and it is extremely confusing. I've brought our best talent in this area, Capt Assessor, to give you the bottom-line briefing and answer any questions you may have."*

Capt Assessor: *"Here's the situation, General Log. We cannot produce an integrated assessment of the logistics capability of our forces to support the potential Orangeland mission. We have asked each functional community in logistics and the Logistics Plans and Weapon System Management Information System (WSMIS) folks to come up with their best assessment. We have gotten several different answers and the functional experts cannot verify the validity. There is a fair amount of debate over which is the right number. Our best military judgment suggests that we are short of a particular preferred munition known as a Framowitz and even if we had it, we aren't sure we have the TRAP (tanks, racks, adaptors, and pylons) to fly that particular mission, but we are asking the TRAP people now."*

Gen Log: *"This is Bull! I fought hard for the Framowitz requirements and dollars in the Program Objective Memorandum (POM). We worked hard to fund the requirement for this kind of contingency and you are telling me we don't have enough?"*

Capt Assessor: *"Yes, you did, sir. But we used a different methodology to build and assess the requirement than we did to allocate Framowitzes to the MAJCOM and distribute them in the theater. We did the requirement assessment using targets killed and allocated based on fair sharing of authorized quantities."*

Gen Log *(showing rising frustration): "Forget all that! Go to the relevant MAJCOM level and get me an answer. If that doesn't work, go to the nearest base and get their best assessment. They ought to be able to tell me quickly what their capability is."*

Capt Assessor: *"Sir, we did both of those things. We got two significantly different answers at the MAJCOM level, and both systems claim to have the right one. One model said we could do it, and one said we couldn't; and we aren't sure what the difference is or why the two are producing different answers. We went to the base level and asked them for a quick analysis and they told us they did not have any assessment tools. They gave us a back-of-the-envelope answer that said we could do it but said they would have a better answer in two weeks if you tell them the exact operational scenario. I guess we will have to go with their quick answer, although no one feels confident about it."*

Gen Log: *"You and your assessment community better get your act together. In the meantime, we'll have to tell the Ops guys we think we can support their effort and let's hope we are right."*

RESULT: *The mission had to be aborted because the appropriate TRAP was unavailable to support Framowitz delivery at that location; and, by the time it was redistributed from a nearby location, the mission window was missed.*

Introduction

Does this sound like a farfetched horror story? It could happen today. Usually, because of dedicated heroics by Air Force personnel, the Air Force is able to avoid serious errors in decision making related to logistics support capability. There are some serious problems, however, some of which must be overcome by changing the way in which capability assessments are performed within the logistics community. This article is about an initiative to solve some of these problems, the Logistics Assessment Architecture.

Short History of USAF Assessment Systems

One of the first assessment systems built for the USAF (in the mid-1970s) was the Logistics Capability Measurement System (LCMS). It was developed in AF/LGXY (now AF/LEXI) at a time when materiel stocks, especially spare parts, were low and logistics capability was measured in "percentage of bin fill." LCMS was developed in response to AF/LG's desperate need to present the situation that the Air Force's operational capabilities were severely limited by logistics shortfalls. General Billy M.

Minter, the AF/LG at the time, said that we knew we were hurting, but when asked how or how much it hurt the capability of the USAF, all we could provide was anecdotes.

Logistics budgets could not be defended with analysis. This case had to be made in operational terms, be based on credible analysis and data, and be straightforward enough to justify to Congress and the general public. This was done at a time when the focus of the Air Force was on force structure issues and logistics was not considered to be very interesting (some would argue this is still the case today).

LCMS was built in a "skunkworks" environment in the Pentagon by a joint team of Air Force and contractor analysts and made several major contributions such as converting spare part inventories to capability over time expressed in flying hours and sorties. It had enough individual spares data to be credible but presented a macro picture to decision makers. It put the "right" operations data in the model and forged a relationship between Operations and Logistics (Ops & Log) that is growing today.

The LCMS effort was very successful and, in fact, has evolved substantially; it is used every day at the Pentagon. It has since become an umbrella concept for a family of models and databases that perform assessments for spares and other commodities at the Air Staff.

In the early 1980s an effort called CAC, Combat Analysis Capability, was started at the Air Force Logistics Command (AFLC) and became the precursor to WSMIS. WSMIS was born and grew due to an ever-increasing focus on weapon system management and capability assessment, continuing the trend away from individual spare part management in the logistics community.

During the 1980s, the USAF became increasingly reliant upon various tools to perform capability assessments. These tools have become vital to making good decisions and have grown in sophistication over the years. With the advent of microcomputers and related technologies, new assessment models and systems have proliferated. While there is still a lot of work to do, significant progress has been achieved in developing the right kind of tools to support decisions.

A Black Cloud

There was a growing concern, however, that amidst all this progress something was wrong. The symptoms included a proliferation of competing assessment tools and techniques that produced answers which were sometimes in conflict. For some logistics commodities, a good model existed at one echelon of the Air Force but not at another level. Sometimes models were inconsistent with basic functional processes; for example, the assessments did not agree with the requirements process. Assessments were seen as the panacea by some and the nemesis by others who were trying to do the "real work" of the Air Force.

Paradoxically, in the face of growing assessment sophistication, improvements in technology, and the availability of more tools and techniques than ever, there were still assessment needs not being met. It seemed as if no one was in charge of taking a top-down integrated approach to developing a consistent set of assessment tools at all echelons, for all commodities, for all functions. In the new fiscal realities of the Defense Department, there is increased pressure to eliminate expending scarce dollars on duplicative or overlapping computer systems.

The growing needs for assessment capability and the increasingly visible symptoms of a major problem were recognized by the senior leadership of the Ops and Log communities. These concerns were addressed at the first DO/LG Conference in the summer of 1989 and more recently at CROSSTALK 90. The taskings that came out of those discussions led to the Logistics Assessment Architecture.

What is a Logistics Assessment Architecture?

The Logistics Assessment Architecture is a vision of a target architecture that promotes integration of decision making across logistics subfunctions and one that meets all assessment needs of the Air Force. The recommendations provide a road map for the logistics community to build a consistent set of solutions over time to meet assessment needs for all commodities at all echelons. These solutions include models, systems, and specific pieces of software built into the basic information systems that manage functional processes. The architecture also encompasses a complementary set of policies and procedures designed to ensure the right model is embedded in the right system. Once the architecture is in place, it must be institutionalized and managed by the appropriate functional leadership.

Why is a Logistics Assessment Architecture Needed?

Today's system is broken and will stay broken until it is fixed. The logistics community needs an overriding architecture to define the needs and solutions for assessment capability, which is why the Logistics Assessment Architecture must be implemented. Perhaps even more importantly, with the Logistics Assessment Architecture in place, there is a better probability of getting the right resource to the right place at the right time to support Air Force operations. If done properly, these tools will serve as the core of logistics systems for planning and execution of resource decisions in war and peace.

The Analysis Approach

The first step in the analysis approach was to ignore the solutions that were already in existence. The fundamental question was: "What assessment questions does the Air Force need to answer?" While there are many dimensions to this question, the focus was upon asking the question for each major process, for each major logistics resource, at each level (base, MAJCOM, Air Staff), in war and peace. The major resources initially looked at were spares; munitions; tanks, launchers, racks, adaptors, and pylons (TLRAP); and fuels. This set of dimensions is depicted in the Assessment Matrix shown in Figure 1.

A specific example of an assessment question is in the part of the matrix related to peacetime munitions funds allocation at the Air Staff. There, almost daily, the question must be answered: "What is the impact on operational capability of a reallocation of planned procurement funding from one type of munition to another?" The Air Staff requires a tool to answer this question. That tool must be able to answer the question consistent with the way the operators (HQ USAF/XO) develop requirements and with the way in which shortfall munitions are allocated to theaters.

Another example is in the spares area. For the MAJCOM level in a wartime distribution situation, the Air Force must know the impact upon the operational capability of a unit due to a shortfall of a critical item, and what the change would be if a subsequent redistribution of that asset was made from a nearby

base (the Air Force must also know the impact on the sending unit).

After working with the relevant functional areas to identify the complete set of questions for each resource/level combination, a set of core assessment needs emerged. These core assessment needs seemed to cut across commodities and apply to all levels. The core assessment needs are shown in Figure 2 using the base level as the example. MAJCOM and Headquarters level versions were also produced and, if shown, would include the addition of a few items to reflect their unique differences from bases.

Once the basic needs were identified, independent of available solutions, existing models and systems were surveyed. The needs by resource area were compared to existing models

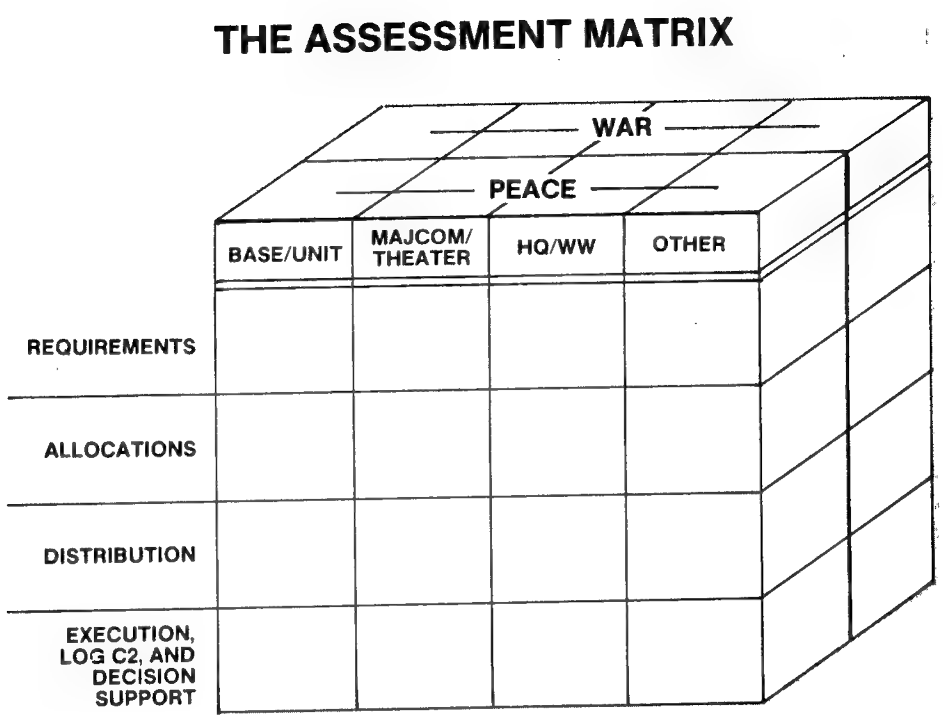


Figure 1. Assessment matrix.

CORE ASSESSMENT NEEDS

	WAR	PEACE
REQUIREMENTS	• DETERMINE MISSION IMPACT OF SHORTAGES IN OPERATIONAL TERMS • EVALUATE CHANGING REQUIREMENT BASED ON CHANGING FACTORS • ASSESS RELATED RESOURCE REQUIREMENTS	• ESTABLISH AND ASSESS BASELINE REQUIREMENTS
ALLOCATION	• DETERMINE SHORTFALL ALLOCATIONS ACROSS UNITS BASED ON OPS PRIORITIES	• ESTABLISH AND ASSESS BASELINE ALLOCATION
DISTRIBUTION	• ASSESS ASSET MOVEMENT PLANS AND IMPACT ON CAPABILITY	• ESTABLISH AND ASSESS BASELINE DISTRIBUTION OBJECTIVE • ESTABLISH AND ASSESS RESUPPLY PLAN
EXECUTION, LOG C2, AND DECISION SUPPORT	• DETERMIND CAPABILITY BASED ON AVAILABLE STOCKPILE AND RELATED RESOURCES • PROJECT CAPABILITY WITH LIMITED INFORMATION • MAKE DECISIONS AND TAKE ACTION	• MONITOR READINESS BASED ON AVAILABLE RESOURCES • MONITOR SUSTAINABILITY UNDER ALTERNATIVE SCENARIO • IDENTIFY SHORTFALLS AND PROVIDE INPUT FOR GET WELLS

Figure 2. Core needs.

and systems to determine which needs were completely met, partially met, or not met at all by those existing models. (Near-term enhancements currently being developed were also considered.)

Figure 3 summarizes the current state of the world and highlights shortfalls in existing assessment capability for both war and peace as well as the inconsistencies and overlaps in different systems/models for each resource area. Once the current level of coverage and problems was documented, a target architecture was designed to correct the existing holes and solve overlap problems.

The Target Architecture

The future solutions are shown in Figure 4 for each of the four basic resource groups. The fewest discrepancies between the current and future architecture are in the spares arena. This is to be expected because of the long history and large body of work that has been performed in this area already. Therefore, the solutions for spares involve retaining Dyna-METRIC Analysis System (DMAS) and WSMIS for the base/unit level; WSMIS, DMAS, Distribution and Repair in Variable Environments (DRIVE), Theater Repair and Distribution Execution System (TRADES), and Spares Wartime Assessment Procedure (SWAP) for the MAJCOM level; and SWAP for the headquarters level. The munitions resource area requires work to enhance the WSMIS Munitions Microcomputer Prototype and then transition it to the Combat Ammunition System - Base (CAS-B) production environment for distribution to all bases. The MAJCOM-level solution is to incorporate the WSMIS Supplemental Munitions model logic into Contingency Operation/Mobility Planning Execution System (COMPES). The headquarters-level solution is to continue the enhancement of the Munitions Assessment Model in LCMS.

TLRAP has many deficiencies in assessment capability. To satisfy the base-/unit-level requirements, TLRAP assessment capability will be integrated with munitions in the WSMIS Munitions Microcomputer Model. At the MAJCOM level, COMPES will be enhanced to include TLRAP assessment algorithms. The headquarters-level work involves enhancement of LCMS with integrated TLRAP assessment algorithms.

Fuels requires the institutionalization in a functional system of the Aviation Fuels Capability Assessment Model (AFCAM) to satisfy base/unit assessment requirements. At the MAJCOM level, LCMS tools will provide an interim solution with the ultimate solution being provided in the AFC2S modernization of Combat Fuels Management System (CFMS). At the Headquarters level, LCMS will be enhanced to provide consistency with CFMS and provide integrated resource assessments including fuels for budget analyses.

Current Status and Future Work

The Logistics Assessment Architecture initiative and its results have been briefed to decision makers at all levels in the logistics community. The basic recommendation to adopt the architecture has been accepted by the functional communities. A road map to get from where the Air Force is today to the target architecture is under development. This involves structuring detailed implementation plans and, wherever possible, influencing assessment work that is ongoing or starting to head in the direction of the Logistics Assessment Architecture solutions. LE plans to continue to "configuration control" the future course of logistics assessment work to ensure the Air Force does not regress to the problems existing today.

CURRENT ASSESSMENT MODELS/SYSTEMS SPARES

	Base/ Unit	MAJCOM/ SPM	HQ/WW
Requirement	WSMIS DMAS	WSMIS DMAS SWAP	SWAP
Allocation	WSMIS DMAS	WSMIS DMAS DRIVE/TRADES SWAP	SWAP
Distribution	WSMIS DMAS	WSMIS DMAS DRIVE/TRADES	N/A
Execution, LOG C2, and Decision Support	WSMIS DMAS	WSMIS DMAS DRIVE/TRADES SWAP	SWAP

CURRENT ASSESSMENT MODELS/SYSTEMS MUNITIONS

	Base/ Unit	MAJCOM	HQ/WW
Requirement		WSMIS LOGFAC	LCMS
Allocation		WSMIS LOGFAC	LCMS
Distribution		WSMIS LOGFAC	LCMS
Execution, LOG C2, and Decision Support	CAS-B	WSMIS LOGFAC CAS-C	LCMS

CURRENT ASSESSMENT MODELS/SYSTEMS TLRAP

	Base/ Unit	MAJCOM	HQ/WW
Requirement		LOGFAC	
Allocation		LOGFAC	
Distribution		LOGFAC	
Execution, LOG C2, and Decision Support		LOGFAC	

CURRENT ASSESSMENT MODELS/SYSTEMS FUELS

	Base/ Unit	MAJCOM	HQ/WW
Requirement			LCMS/THEATER PROTOTYPE
Allocation			LCMS/THEATER PROTOTYPE
Distribution			LCMS/THEATER PROTOTYPE
Execution, LOG C2, and Decision Support			LCMS/THEATER PROTOTYPE

Figure 3. Current assessment models/systems.

The architecture was built to be expandable to other echelons, resources, and organizations. The basic goal is to extend the Logistics Assessment Architecture to cover all echelons, including Joint; all combat critical resources; all major functions; and all states of the world. States of the world here refer to war, crisis, and peace.

The next highest priority for extension is the application of the analytical approach to integrated assessments across resource areas. The DO/LG working group has also suggested that the Operations assessment architecture be analyzed in comparison to the Logistics Assessment Architecture to determine where overlaps, inconsistencies, and problems may exist to ensure Ops-Log consistency of assessments in the future.

The original initial analysis included a quick look at the Joint echelon. The result suggests that many challenges and opportunities exist to correct inconsistencies in the Air Force and Joint assessment architectures.

Finally, there are other resources which must be analyzed within this framework. The wartime, crisis, and exercise portions of logistics capabilities require further enhancement. This future effort is being prioritized and worked in HQ USAF/LEXI.

EPILOGUE

TIME: *ALA2 (After the Logistics Assessment Architecture is implemented).*

RESULT: *Capt Assessor discovered through the application of consistent models that there were sufficient spares, fuels, and munitions to support the operator's requirement for 30 days. However, the lack of a rack to hang the munitions would limit the Air Force's sortie capability to seven days. The assessment model identified a source for the rack from other nontasked Air Force units and they were able to redistribute assets in time. Result—the operation was a success. Capt Assessor became an instant hero and the Logistics Assessment Architecture paid for itself many times over. Gen Log congratulated Captain Assessor and the rest of the Air Force assessment community for "finally getting their act together."*

Individuals too numerous to mention at the Air Staff and at Synergy were instrumental in helping to bring this project to fruition. Without implicating them for any errors which may remain, the authors wish to thank those individuals.

FUTURE ASSESSMENT MODELS/SYSTEMS SPARES

	Base/Unit	MAJCOM/SPM	HQ/WW
Requirement	WSMIS DMAS	WSMIS DMAS SWAP DRIVE/TRADES	SWAP
Allocation	WSMIS DMAS	WSMIS DMAS DRIVE/TRADES SWAP	SWAP
Distribution	WSMIS DMAS	WSMIS DMAS DRIVE/TRADES	N/A
Execution, LOG C2, and Decision Support	WSMIS DMAS	WSMIS DMAS DRIVE/TRADES SWAP	SWAP

FUTURE ASSESSMENT MODELS/SYSTEMS MUNITIONS

	Base/Unit	MAJCOM	HQ/WW
Requirement		COMPES/ LOGMOD CAS-C	LCMS/MAM
Allocation		COMPES/ LOGMOD CAS-C	LCMS/MAM
Distribution		COMPES/ LOGMOD CAS-C	LCMS/MAM
Execution, LOG C2, and Decision Support	CAS-B	COMPES/ LOGMOD CAS-C	LCMS/MAM

FUTURE ASSESSMENT MODELS/SYSTEMS TLRAP

	Base/Unit	MAJCOM	HQ/WW
Requirement		COMPES/ LOGMOD	LCMS/MAM
Allocation		COMPES/ LOGMOD	LCMS/MAM
Distribution		COMPES/ LOGMOD	LCMS/MAM
Execution, LOG C2, and Decision Support	TLRAP MICRO MODEL	COMPES/ LOGMOD	LCMS/MAM

FUTURE ASSESSMENT MODELS/SYSTEMS FUELS

	Base/Unit	MAJCOM	HQ/WW
Requirement	AFCAM FAMS-B	AFC2S/ CFMS	LCMS/FUELS MODULE
Allocation	AFCAM FAMS-B	AFC2S/ CFMS	LCMS/FUELS MODULE
Distribution	AFCAM FAMS-B	AFC2S/ CFMS	LCMS/FUELS MODULE
Execution, LOG C2, and Decision Support	AFCAM FAMS-B	AFC2S/ CFMS	LCMS/FUELS MODULE

Figure 4. Future assessment models/systems.

[illegible] A Future for Human-Centered Design

[illegible]
Air Force Human Resources Laboratory [illegible]
Wright-Patterson AFB, Ohio 45433-6503

This paper describes what human-centered design technology might be able to contribute to logistics system engineering in the distant future. The objective is to promote interest in a serious but technically dense topic through a humorous and plainspoken story. No warrant should be implied for the ultimate feasibility of every capability envisioned here, but all of them are being worked on at AFHRL and elsewhere at this moment. Some are included in new research by the Logistics Systems Branch under Work Unit 2940-03-05 entitled Design Evaluation for Personnel, Training, and Human Factors (DEPTH), toward whose progress the reader's attention is especially invited.

Somber clouds drape day's last light
The tempest's gloomy shrouds in sight
Waves to rumble, winds to roar
Seastorm's violence rolls ashore
- Eboly

Kate May was driving back to her office when the downpour began. She could barely make out the Stone Harbor exit as she inched along the Parkway. She hopscotched over the rain puddles in the deserted parking lot and rushed through the door of Pepamar Technologies. Her clothes had gotten only a little damp. "Next time an umbrella. Could have ruined my new jersey," she muttered to herself as she opened her office door and switched on the computer workstation.

A disembodied voice is heard. "Good morning Miss May."

"You mean good evening, don't you? Bonehead computer. Besides, it's not so good. It's raining cats and dogs tonight."

"Cannot parse...wait...user input post scan...analysis... undefined folk idiom...probable hackneyed metaphor...retry... Good morning Miss May."

Annoyed now, Kate reprogrammed the computer's clock. It flashed "8:40 P.M. June 18, 2001." Then she decided to toggle from automatic speech synthesis mode to manual keypad/mouse mode for person/machine interaction. A glitch like this one would mar the demonstration of the **P**rototype **O**n-Screen **E**rgonomic **T**echnology. Kate had returned to the office that night to run the **POET** through its verses one last time. She wanted everything to be perfect for the Critical Design Review (CDR) the next afternoon, and she was naturally a little nervous.

Six months earlier, Pepamar had received a subcontract from Orchard Industries to develop the complete Personnel Subsystem for the new Macintosh Air Vehicle, or MAV. The MAV was competing against the Crump Air prototype, The Karla, to win the contract to upgrade the USAF Advanced Technical Fighter. Orchard's MAV was leveraged heavily on Pepamar's POET human-model to edge out The Karla in the upcoming logistics simulation trials of the two virtual prototypes. Under the new acquisition rules, the results of these computer-based logistics flyoffs would have equal weight with the results of cost and performance simulations in production contract decisions. Kate had guided the POET from its beginning as a research project in Pepamar's Simultaneous Imagineering Works a few years earlier. The POET had already shown its mettle several times over the past year in Pepamar's business with the USAF Aerospace Logistics Centers (ALCs). The ALCs had become more important in military acquisition when the national strategy shifted from new systems to redesign and modification of existing systems. But Pepamar's future depended on POET's success with the MAV in the system upgrade market.

The Personnel Subsystem was an ancient concept from the previous century. Kate had come across it once in a dusty old textbook on System Engineering. It had to do with defining the role of people in operating and maintaining equipment, with designing machines to take human abilities into account, and with planning and managing the work force to assure the effectiveness and economy of a system over its useful life. In short, it meant including the performance of people when reckoning system performance.

The contribution of "human factors" to system effectiveness was well known back then. And everyone agreed that about 40% of life cycle costs of most military systems were in "human resources." Yet it was often hard to get industry designers and their government counterparts to pay much attention to people issues when new systems were being considered. Human-centered design was too hard and too expensive, it was said. The Personnel Subsystem eventually fell by the wayside. But now, thanks to a wise research investment strategy, new technologies like POET were creating a powerful human-centered design capability. And thanks to the emphasis now placed on people issues in the quality-minded acquisition ethos, the defense industry now placed a premium on human-centered design. The Personnel Subsystem was brought back.

Kate made a quick off-line inspection of the workstation's major subsystems to make sure they were all functioning properly. Everything checked out fine. She clicked on the main menu. The user interface language options appeared first: English, Japanese, and Pan-European. Kate clicked on the English option. The 30-inch high definition monitor displayed four menus down the left side, as well as a guide menu.

SUBSYSTEM CAD DATA PORT **HUMAN MODEL/TASK ANALYSIS** **DESIGN ADVISOR** **LOGISTICS DATA PORT**	**POET's CORNER**

Kate clicked on the guide. POET's Corner was designed to function like an owner's manual, but to be understandable. An overview of the POET system scrolled into view. She accidentally toggled-on the disembodied voice, which read aloud in default Story Mode:

OVERVIEW: POET will help you perform an accurate and thorough human-centered evaluation concurrently with engineering design. You are using a super-fast computer graphics workstation with ultra-expanded random access memory (RAM) capable of producing accurate, realistic simulations of people doing tasks. The workstation contains a number of tools that can help you discover, visualize, and document the maintenance tasks required for a given subsystem design and to describe their ability requirements—physical, perceptual, and cognitive.

The POET-analyst has to know a good deal about human sciences because this technology only assists in task analysis. POET does not do the analysis itself or replace human expert judgment. Knowledge of firmware engineering is not needed, but you should know how to program in SONNETS, the POET's high-level artificial intelligence (AI) language.

"Do you want to hear about the four workstation functions now?"

"Yes, please," Kate answered absentmindedly.

"Oh! Good morning Miss May!"

"That bug is still there! Or is it a virus?" Kate mused. She toggled-off the voice and read in silence.

Subsystem CAD Data Port - Allows you to recreate computer-aided design (CAD) drawings on the display. You may telelink with external CAD machines that use the Product Data Exchange Standard (PDES) or you may use the POET's electronic drafting board to input equipment geometry. You may work at the piece/part, subsystem, or system level of detail depending on your objective.

A Universal Work Unit Code (WUC) HyperBook identifies all equipment groups in a hierarchical arrangement. This allows you to call up a drawing of, say, an engine (WUC Area 23XXX) in its installed state or components of the engine like the afterburner assembly (23ABF). You should have access to any engineering notations about the drawing.

You may change the CAD geometry or other features of the proposed design any way you wish using the POET's CAD graphics software. This will allow you to portray and analyze human/machine problems as well as their solutions. Changes to CAD images are only "local." The Chief Imagineer has sole authority to change an official CAD drawing. Annotate a CAD drawing if there is a problem. But it is better to use the graphics simulation. That way the Chief Imagineer can view the problem and the proposed solution, and be persuaded. Seeing is believing, they say.

"DO YOU WANT TO SEE THE NEXT WORKSTATION FUNCTION?" "YES"

Human-Model/Task Analysis - This is the POET's soul. The workstation has a resident human-model that can be called up in different sizes and guises to interact with the CAD equipment renderings. The graphics simulation provides direct visual information about the physical, perceptual, and psychomotor requirements of proposed person/machine designs. There are, in addition, numerous aids to task description and analysis to enrich this visual task simulation technology. Let's look at all of these by opening up the submenus.

Instantiate Human-Model. A realistic-looking person is created from geometric modeling of basic skeletal "links." Special algorithms are used to enflesh this skeleton and to simulate clothing and other gear a maintenance person might wear. A 3-D illusion is created by color shading and related software artistry.

Define Body Type. The human-model can be drawn to accurately replicate the average physical dimensions of any target population or percentile gradations within that population. The workstation has current data on USAF maintenance populations internally which is used as the default anthropometry.

Strength Data Library. The average maximum force that can be generated by each population group in each of 12 common body postures for each of 40 common maintenance tasks is catalogued.

Tool Crib. The geometry, weight, and operational logic of the nine standard hand tools authorized for U.S. Aerospace Force maintenance are stored here.

AGE Shed. All ten of the currently authorized Aerospace Ground Equipment (AGE) types are available for graphics imaging. These include the Multifunction Combat Turn Servicing Cart, the Engine Puller, and the Integrated Maintenance Information System (IMIS) Computer Support Vehicle.

Detailed Hand Model. For "close in" visualization of manual work, an anatomically exact hand model may be substituted for the polyhedral representation of the human-model's hands.

Vision Model. You may view the work environment as the human-model sees it or as an outside observer. The usual array of human-modeling graphics display technologies are also available with the vision model: any-angle perspective, "zoom," slow motion, and so on.

Team Work. The POET workstation can instantiate up to three human-models of any size who can be made to behave independently but cooperatively in simulating work tasks. This capability aids task design and is used to verify and document task crew size decisions, an important consideration in sizing maintenance manpower.

Animation. You can create realistic human movement simulations in several ways. The following metaphors can be mixed or used alone:

Automatic Transmission. The most common movements involved in USAF aircraft maintenance have been carefully studied and converted to "Crew Chief Notation." This is analogous to a choreographic score. It allows automatic task composition to be reduced to software code to drive a standardized body motion path and sequence. Variations in movement are not allowed and the animated sequence may appear unnaturally regimented. But for some task analysis purposes, such as predicting task times on highly proceduralized tasks, this may suffice.

Manual Transmission. Put on Data Gloves and you can move the human-model's hands and fingers as if they were your own. Kinematic motion transducers in the Data Gloves signal the human-model to move in the same way you move. This animation mode affords a realistic close encounter with the simulated task environment. This illusion can be enriched with other virtual experience technology for temperature, vibration, and pressure representation. For some simulated tasks, the POET's synthesizer can generate sounds that simulate the aural environment. When used with the vision model, the Data Gloves allow you to enter the human-model's virtual world and experience it first-hand. (No pun intended.)

Overdrive. The human-model can be made to perform discrete movements such as reach with arms, turn head, sit, stand, walk, and pick up objects. In detailed hand modeling mode, a variety of common manual tasks for "knobs and dials" (operator) and "nuts and bolts" (maintainer) work can be portrayed. Fifty of these movements are stored as animation primitives. They are implemented through the speech synthesizer or keypad command macros.

Cruise Control. The POET can simulate an "intelligent" agent who appears to behave purposefully, naturally, and autonomously according to some logical plan of action. The agent will act and react according to user-defined "rule books" or AI planning models. The task environment must be carefully defined beforehand.

The human-model will avoid errors (walking in front of a running engine's air intake) and choose adaptive behaviors in logical order (remove cover before removing holographic heads-up display).

Task Analysis Technology. When you have adequately simulated a maintenance task through some combination of the technologies already discussed, you are able to conduct and document a thorough "prescriptive" task analysis. Below are some of the human factors criteria that can be evaluated with the help of the embedded task analysis aids:

Task Design: Determining the right or best way of doing a task, given the current design constraints.

Job Design: Determining, across a whole system, how tasks should be grouped, and how task groups should be allocated to job specialists. Used best with the SUMMA Manpower Simulator.

Task Manning: Determining the minimum task crew size to carry out the work safely and efficiently. Important in human resource costing.

Task Time Line: Placing the task elements in logical, timed sequence and showing a whole task from start to finish, along with its relationship to other tasks.

Task Abilities: Determining the human abilities required to learn to do the task effectively. These include physical, psychomotor, and cognitive abilities. Some of these can be determined from visual inspection of task simulations. Others can be inferred with the help of the Design Advisor, who keeps a skills taxonomy for you.

Task Conditions: Specifying the tools and support equipment required, their manner of use, special safety considerations, and allowable variations in task procedures.

Task Prescription: Determining how a proposed design can be improved from a human factors point of view and simulating the effects of a proposed redesign. You may get help from the Design Advisor in cases where solutions are not obvious from direct visual inspection.

In sum, the POET's motive is to let you infer what the proposed work for a proposed design will be like by letting you see it. It allows you to do task analysis early, accurately, and thoroughly without costly physical mock-ups. If you can know what the maintenance work will be like early in design, before hardware is actually fabricated, you can help designers avoid costly mistakes. In so doing, you will help reduce design development time and cost. But more, you can help make good designs into great designs by using computer technology to transform pedestrian task analysis into inspired POETry.

"DO YOU WANT TO SEE THE NEXT WORKSTATION FUNCTION?" "YES"

Design Advisor - This is an intelligently interactive array of human performance data stores. It consists of scientific facts, design standards, contract specifications, maintenance lessons learned, and detailed information about the USAF work force. The hypermedia technology allows this diverse knowledge base to be marshalled and presented in useful ways. The Design Advisor will help you make reasoned inferences about human task performance capabilities and limitations for specific design problems. It will help assure that you match workstation analysis results with formal contract requirements. The Design Advisor is on call through windowing software anywhere in the POET system. Some of the data stores and inferencing aides handled by the Design Advisor are:

Results of Meta-analytic Literature Surveys. This file displays summary statistics covering 120 of the psychological variables known to account for performance variation in 180 laboratory and applied tasks most relevant to military maintenance. These statistics are computed over the entire range of research studies ever published in the 136 journals sanctioned by the International Congress of Simultaneous Imagineers. The rate of knowledge accumulation has increased markedly since original, empirical behavioral research was banned and efforts to unify the scattered knowledge base in the behavioral sciences were mandated instead.

Maintenance Data. The USAF Advanced Core Automated Maintenance System (CAMS) provides accurate and complete data on field experience with existing deployed systems. How often an item breaks, how it breaks, how long it takes to repair, and who repairs the item are all available through simple queries. Total Quality Management (TQM) goals for all systems, new or modified, are now tied to maintenance experience with systems already in use. In the past, logistics improvements were projected based on engineering theory or unaided expert judgment. Having real-world data on existing systems at hand will allow more accurate prediction of the logistics behavior of modified systems.

Knowledge Search and Rescue. The Design Advisor can quickly capture the state of knowledge applicable to any given human performance issue in human-modeling. The entire human performance data store is cross-indexed. Natural language query is supported. For example, the user may ask: "How many things can a person pay attention to at one time?" The Design Advisor may reply: "The answer used to be seven, plus or minus two. But it's less clear now. Whose experimental paradigm do you favor?" By entering into this Socratic dialogue, the user will easily discover what scientific knowledge has to say about a particular design evaluation issue.

"DO YOU WANT TO SEE THE LAST WORKSTATION FUNCTION?" "YES"

Logistics Data Port - If the CAD Data Port could be thought of as input, and the Human-Modeling/Task Analysis and Design Advisor as data processors, then the Logistics Data Port could be thought of as the output. From this perspective, POET is an aid for:

Specifying Tasks:	Using CAD and human figure graphics technology.
Analyzing Tasks:	Using information automation for aided inference.
Documenting Tasks	Using data management technology for human resource planning and for certain "downstream" analyses.

Both design influence and design documentation functions for maintenance are exhaustively covered by the Logistics Support Analysis (LSA) process through the Logistics Support Analysis Record (LSAR). The LSAR is vital for resource planning for weapon system support, including the "downstream" manpower, personnel, and training (MPT) or human resources planning functions. The interface is created by linking an LSA data model with the POET human-modeling technology.

The successful implementation of the Computer-Aided Acquisition Logistics Support (CALS) initiative in the last century eliminated paper-based documentation. CALS also achieved real economies in managing, updating, and distributing system support data, especially maintenance

technical data, to the field. Human-modeling technology applied during design can greatly expand the value and efficiency of CALS in our own century by providing more accurate and complete LSAR information on the human side of systems.

The Logistics Data Port in POET supports the following human resources analysis and documentation functions at the moment:

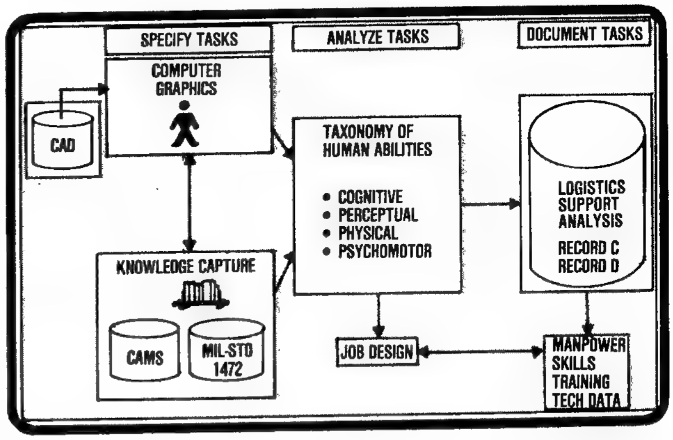
System Manpower Requirements. To use this simulation most effectively, you need to have manpower-relevant factors for the entire system under review. If you are looking only at individual subsystems, this simulation will give an incomplete picture. The simulation will project unit manpower requirements and costs using as input the task analysis information of crew size, reliability and maintainability (R&M) parameters, and system utilization rate. The embedded manpower simulator, called SUMMA, is created using object-oriented software technology. SUMMA operates in tandem with the Job Design module of the POET's Task Analysis Technology. Trade-off studies among job scope, equipment reliability, and manpower requirements can now be performed quickly and accurately. The entire manpower "data build" and simulation process for the MAV took just one person two hours. It used to take four people four months. This huge increase in software productivity has at last created a design interactive role for maintenance manpower. "Downstream" analyses for human resources have moved "upstream."

Training Development. The 3-D color workstation graphics are ideally suited to the twenty-first century CALS technical data mission. By using only the common fiber-optic/satellite telemedia and PDES standards, accurate and up-to-date maintenance graphics can be created for use in many locations for many training applications. For example, the data can be relayed to IMIS support vehicles on USAF flight lines across the globe, almost instantly, to keep maintenance tech data current with engineering changes. The task simulation graphics can be screen-dumped to compact laser disks or videotaped in hologram format for distribution from ALCs to USAF technical schools, to on-the-job training sites, or to the new "Virtual Training Centers." Technical training for many maintenance jobs no longer requires the use of expensive prime equipment for "hands-on" demonstration and practice. Computer graphics technology used in its place has made USAF training more effective, much less expensive, and much more abundant.

The POET hesitates to use hackneyed sayings, but the two key ideas for training are that a picture is worth a thousand words, and that you learn by doing. The Design Advisor does not equivocate in confirming these ideas, although his language can be more professorial. He might say that an emergent cognitive structure with synergistic potential is created when high-fidelity instructional stimuli are presented through the visual and psychomotor modalities simultaneously.

LSAR Data Management. All task description and task analysis data applicable to Personnel Subsystem definition are automatically written to ASCII files for upload to the LSAR. This MIL-STD 1388-3D data system, now available much earlier in the design cycle, provides a complete, authoritative repository of current, validated logistics information. There is no paper, no lost data, and no updating problem. Data management costs are reduced, and planning for system maintenance and support by Air Logistics Centers is vastly improved. Because the LSAR database is under TQM protection, it is available for human-centered analysis for all redesign opportunities created by system modifications, upgrades, and mission changeovers. Of course, major new systems will benefit from better LSA data management too, though these applications are admittedly not as glamorous or important.

"DO YOU WANT TO SEE THE OVERALL POETic VISION?" "YES"



"LEAVING POET'S CORNER NOW. RETURNING YOU TO MAIN MENU."

"DO YOU WANT A CURRENT EVENTS UPDATE ON THE WAY?" "YES"

**** News Wire	Pepamar refuses Crump's request for POETic license. Crump offers 14 billion Euroyen in buyout attempt.
**** Weather Vane	Raining cats and dogs tonight Humane Society overwhelmed with calls. Moonshine toward daybreak.
**** Sports Desk	Yankees defeating Reds by tie score, 2-2. Washout.Crump announces Yankees will move to New Jersey.

Kate ignored the news. She was already configuring the workstation for Demo Mode. She wanted to rehearse tomorrow's CDR presentation. The screen dimmed slightly during the brief moment it took to load the laser-graphics Data Pack. But everything seemed to be working fine.

Kate navigated through the POET's visual and verbal reports for each subsystem of the MAV. She used the Work Unit Code HyperBook to identify equipment and maintenance tasks. She didn't notice the hours passing. Kate had been told that the people from Orchard would be especially interested in the Personnel Subsystem definition for the MAV's propulsion subsystem, so she called up the Engine Sector for detailed review.

The workstation produced animated 3-D color graphics of engine maintenance tasks as Kate rattled off "action-object" keypad commands defining flight-line maintenance work. She stopped the displays after a while and ordered the human supportability Warnings and Cautions Report for the engine. The screen went blank for a moment. The thought of computer infection briefly entered her mind. Then—

Engine Warnings & Cautions Report

1. Engine remove/replace task needs four people, any ability group. But contract specification requires three people. Design Advisor counsels redesign of Engine Puller AGE. Two people could do this task with greater use of robotics. Manpower impact is 4 percent overall

reduction in human resources life cycle cost. Feasibility of Engine Puller redesign not known. Mechanical Engineering CAD cell notified of opportunity.

2. Relocate bore scope port to accommodate 5th percentile female stature. Result: Ladder AGE will no longer be needed for inspection task. Task time reduced 40 percent, confirmed by graphics resimulation. Combat quick-turn time reduced 15 percent, now = 14 minutes.

3. Engine duct work found to interfere with maintenance of synfuel pump. Adds 2.5 hours to any pump maintenance action because duct work must be removed for access. Reliability and Maintainability team projects high frequency of maintenance and lengthy repair time. Task Design Module projects three people, two different specialists. Prescription: Place pump on outside. Result: Structural repair specialist is no longer needed. Two people needed, 5th to 95th percentile body size. Eliminate 2.5 hour "time tax" on pump maintenance. SUMMA Manpower Simulation shows 3 million Euroyen cost avoidance in MAV human resource category through this simple design change. Greater R&M expenditure on synfuel pump design is now justified. Chief Budgeteer notified.

4. Color-coded built-in test warnings on diagnostic panel cannot be discriminated under glaring desert sun conditions or when wearing chemical defense visor. This may lead to catastrophic engine failure. Prescription: Design Advisor recommends positive switch with redundant iconic display instead of unaided color codes. Hard copy Lessons Learned narrations and human factors literature citations for CDR discussion are available at Data Store Checkout Counter.

5. The afterburner synfuel injector assembly appears to have mysterious failure modes that cause simulated maintenance persons to engage in "superstitious" and other maladaptive maintenance actions. They either give up entirely or else change out assemblies regardless of the reported fault. Cognitive mark-up on injector assembly work indicates need for high tolerance of ambiguity and heuristic decision-making skills. These personnel skills far exceed the projected talent budget. Design Advisor is perplexed. Prescription: Maturational testing of injector assembly to fully reveal all failure modes and permit proceduralization of all maintenance tasks. Else enroll mechanics in Harvard Executive Development Center.

Kate suppressed the rest of the engine report and went on to the MAV total supportability summary. This would show the big picture on human aspects of MAV performance.

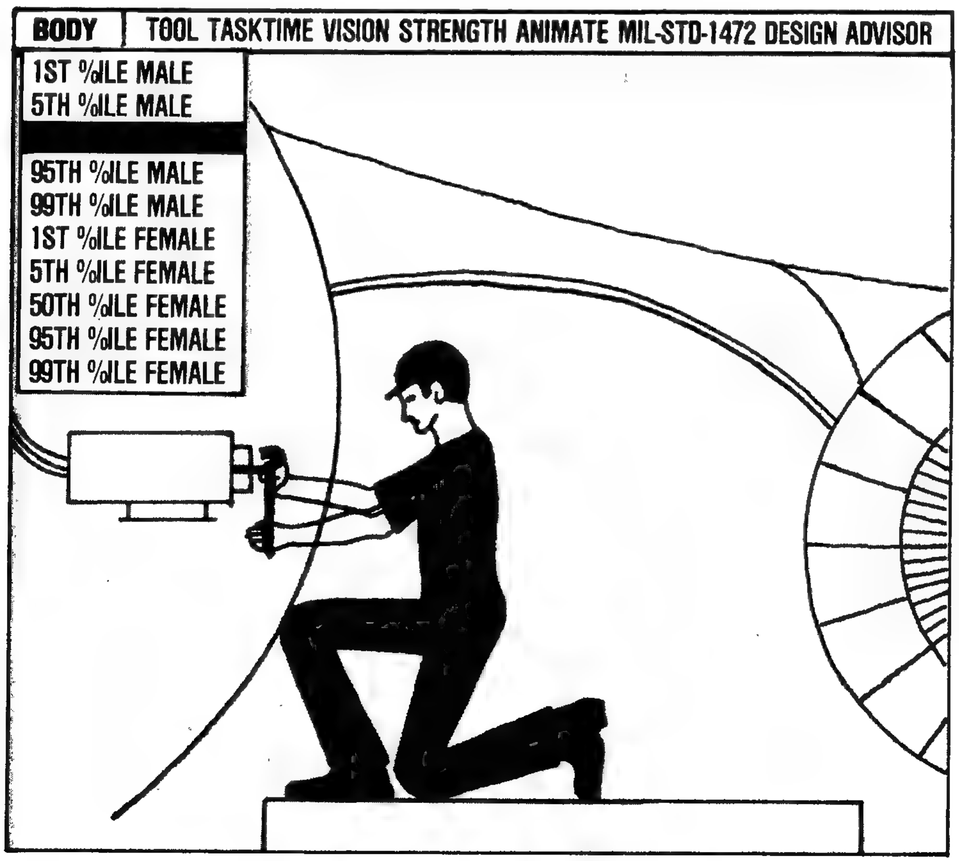
MAV Big Picture

Maintenance Human Resources	**4 spaces per MAV**
Human Factors Problems Found	**345**
Human Factors Problems Solved	**345**
MAV Design Development Time	**6 months**
MAV Design Cycles	**17**
Cost Avoidance Using POET	**435 million Euroyen**
Cost of POET Application	**.3 million Euroyen**
Combat Capability Value Added	**2 more sorties per day**

Kate was satisfied. The POET had performed eloquently. Her only worry now was the POET's speech synthesizer. But that could be toggled-off. Kate looked out to the parking lot. Above, a sea breeze chased the last of the storm clouds from the starlit sky. Below, white moons danced in reflected merriment on the black rain puddles. "A thousand points of delight," Kate beamed. Tomorrow would be a beautiful day in every way. "Guess I'll call it a night, or a morning, actually," she yawned alarmingly at the clock. It was 4 A.M. Kate took one last look around the room. Everything in order. The workstation switched itself to Standby Mode. Kate turned off the lights and heard the door close behind her. She did not hear the disembodied voice in the darkened room.

"Good morning Miss May."

Golden sun greets silver strand
Zephyr's arms embrace the land
Rousting storm-tossed reverie
Morning wakes and smiles on thee.
Eboly



Supportability Investment Decision Making: A New Look at an Old Dilemma

Lieutenant Colonel Robert Materna, Ph.D., C.P.L.
Assistant Professor of Logistics Management
School of Systems and Logistics
Air Force Institute of Technology (AFIT)
Wright-Patterson AFB, Ohio 45433-6583

Anyone who has been involved in managing logistics projects is well aware of the difficulty of obtaining accurate information on the many variables which frequently affect the decision-making process. In recent years, however, a new problem has emerged. New technology, in the form of extraordinarily powerful mainframe to desktop computers, combined with similar advances in software development, has resulted in a plethora of computer-based logistics decision-making tools. In fact, Mr. Thomas E. Schering, an Operations Research Analyst at the Defense Logistics Studies Information Exchange (DLSIE), reports that there are approximately 6,900 references to logistics related models in the current DLSIE inventory.[1] And this is not just a DOD problem. The most recent edition of *Logistics Software*, for example, identifies 765 commercially oriented logistics software packages offered by US companies and an additional 491 packages from various international vendors.[2]

As stated in one recent article on this subject, in many ways it is both the best and worst of times.[3] On the one hand, we now have access to a powerful new array of technologies to assist in the decision-making process; but, at the same time, there has been no real framework for applying or integrating these advancements. Developing such a framework within the DOD is no easy task, since such decisions tend to vary by type and magnitude of program, phase of the life cycle, functional area, and many other factors. Complicating the issue even more is the fact that military logisticians are increasingly being forced to make important investment decisions with less time and fewer resources than in the past. The US Air Force has been struggling with this difficult problem for years, and this article addresses one approach for dealing with this dilemma; i.e., the development of a centralized Supportability Investment Decision Analysis Center (SIDAC) to assist Air Force mangers in analyzing and prioritizing supportability investments to meet Air Force needs.

The SIDAC Concept

In an effort to deal with this increasingly complex situation, the Air Force Logistics Command Logistics Operations Center (AFLC LOC/TL) and the Wright Research and Development Center (WRDC/TXL) funded an investigation into the feasibility of establishing a SIDAC at, or near, Wright-Patterson AFB, Ohio. The Information Analysis Center (IAC) concept is certainly not new, and at the present time there are more than 20 chartered IACs dedicated to a particular discipline or mission throughout the DOD.[4]

The primary purpose of SIDAC would be to develop and maintain a center of expertise capable of applying and improving analytical models, methods, and services for virtually every aspect of weapon system supportability and to enhance the associated decision-making process. More specifically, such a concept would facilitate the exchange of information between the Air Force Logistics Command, the Air Force Systems Command (AFSC), and other communities; promote the awareness and use of appropriate analytical techniques; eliminate or minimize technical barriers which limit the effectiveness of applying such techniques; assist in identifying and accessing quality data and information; and influence the design of future information and data systems to better serve the community.[5] The need for such services was recently validated through over 180 interviews with key personnel from 22 Air Force and DOD organizations.[6]

Figure 1 is a functional overview of the SIDAC concept, where one can see that the technical resources and capabilities of SIDAC, supplemented by a communication gateway, have been designed to provide a structure for evaluating logistics supportability investment decisions.[7]

SIDAC technical capabilities would include a family of analytical procedures and guidelines to assist investigators in evaluating supportability related issues; models and simulations which have been used in past studies; access to data sources and selected preprocessors; and, finally, user-friendly software to assist the customer in being able to access and use these services. Furthermore, the center would be staffed with experienced personnel who are trained to provide assistance in how and when to apply SIDAC resources. This in-house expertise would be supplemented with a source library and information database to support the SIDAC community.

SIDAC's proposed organizational concept is presented in Figure 2 where external direction would be provided on a periodic basis through a Steering Group consisting of representatives from AFLC, AFSC, AFIT, other USAF major commands, and the US Army and Navy.[8] The Air Force Management Integration Office (MIO) would direct the day-to-day activities of the office and would be staffed by personnel from AFSC and AFLC. The MIO, in turn, would be supplemented by contractor personnel to answer technical questions and perform special studies as required.

Using data from AFLC management information systems and other sources, SIDAC would house or have access to a wide variety of models including the All Mobile Tactical Air Force (AMTAF) Model, the Dynamic Multi Echelon Technique for Recoverable Item Control (Dyna-Metric) Model, the Logistics Assessment Work Station (LAWS) System, the Logistics Composite Model (LCOM), the Methodology for Analyzing Reliability and Maintainability Investments (MARMI) Model, the System Cost and Operational Performance Evaluation (SCOPE) Model, and the Theater Simulation of Airbase Resources (TSAR) Model, plus others as SIDAC's database increases.[9]

Typical situations in which this concept might be applied include weapon system master planning, modification ranking, technology transition evaluations, trade studies, and budget

allocation decisions. Other related applications may involve reliability and maintainability (R&M) analyses, repair level evaluations, manpower and personnel decisions, life cycle cost studies, mobility evaluations, and return-on-investment (ROI) decisions. In fact, a recent article in the *Air Force Journal of Logistics* described yet another example of how SIDAC services could have been applied to assist in performing a spares assessment on the F-16 aircraft using Dyna-Metric.[10] If, for example, the authors had needed assistance in planning and performing their study, SIDAC personnel could have been directly consulted to determine if similar work had been previously done and to provide direct assistance, if necessary, in applying the appropriate model to perform their assessment. Even if the direct assistance of SIDAC personnel was not needed, SIDAC's information base, newsletter, source library, and conferencing ability could have been used to disseminate and

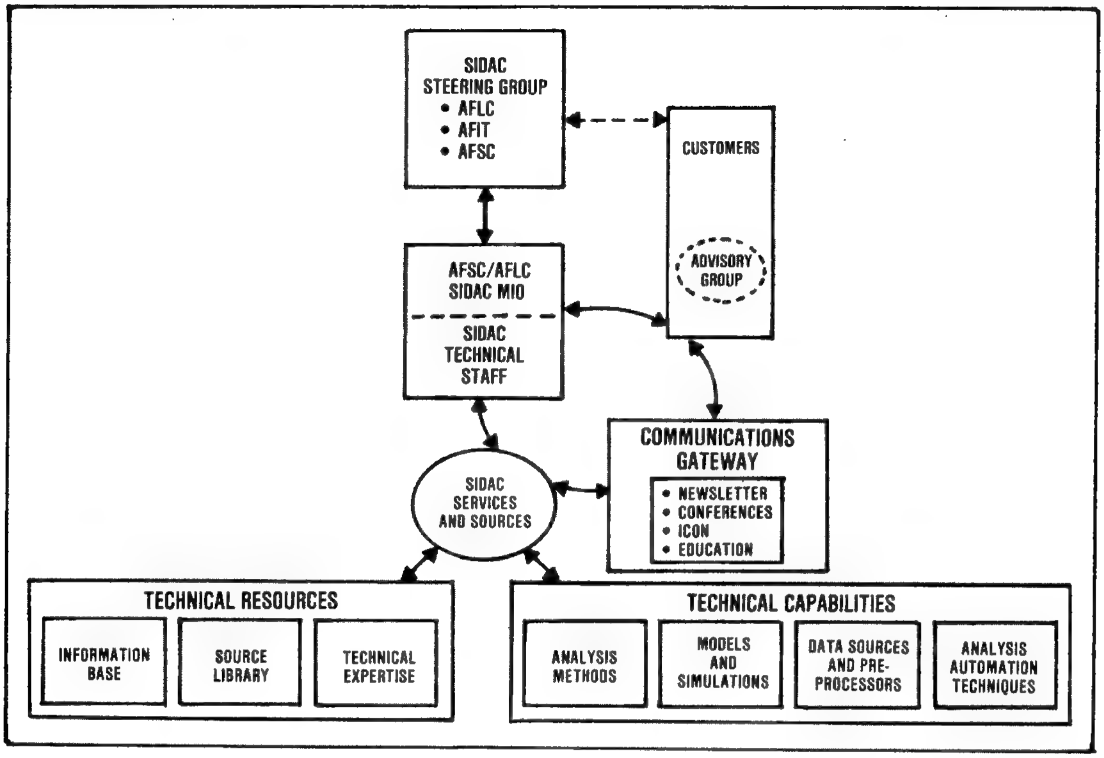


Figure 1. Functional overview of SIDAC.

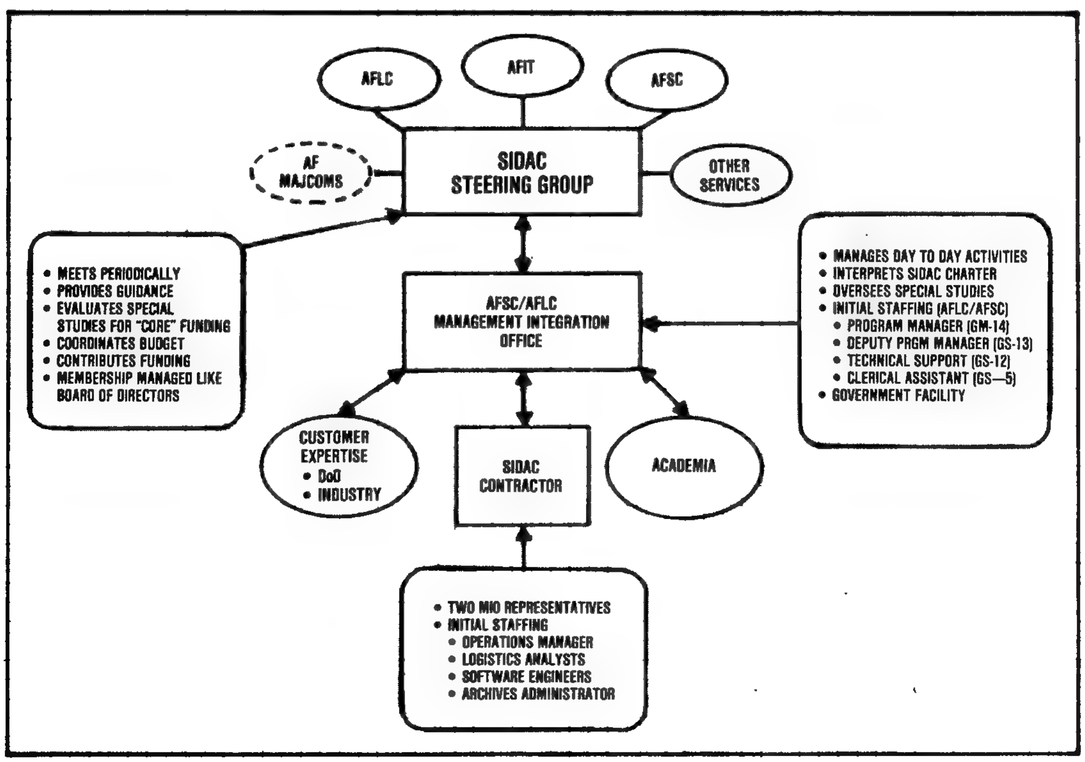


Figure 2. Proposed SIDAC organization.

permanently store the methodology and results of the study for the benefits of future analysts and decision makers throughout the USAF and DOD.

To illustrate more clearly how this concept can work, the following section describes how a proposed SIDAC resident prototype logistics assessment software package was applied to a battery replacement analysis on the F-16 "A" and "B" series of aircraft.

Applying SIDAC: An F-16 Battery Replacement Analysis

The purpose of this study was to perform a "proof of concept" analysis on a "real world" problem using government-owned software. For a number of years, the Air Force has been concerned about the reliability and maintainability characteristics of the F-16 A/B battery system. As illustrated in Figures 3 and 4, the existing battery is one of the most frequently failing and manpower intensive systems on the F-16.[11]

NO.	WUC	DESCRIPTION	MTBF
1	11000	Airframe	14.26
2	12DAA	MLG Wheel Assmbly	14.28
3	75CB0	Launcher Wing Tips	29.80
4	74DA0	Inertial Navigation Unit	44.04
5	42GAA	Battery	53.54

MLG—Main Landing Gear
WUC—Work Unit Code
MTBF—Mean Time Between Failures

Note: From 1/89 through 8/89

Figure 3. Top five failing systems by work unit code (WUC).

NO.	WUC	DESCRIPTION	MMH/FH
1	11000	Airframe	.41
2	23Z00	Engine	.24
3	74DA0	Inertial Navigation Unit	.21
4	42GAA	Battery	.14
5	75CB0	Launcher Wing Tips	.12

WUC—Work Unit Code
MMH/FH—Maintenance Man-Hours/Flying Hours

Note: From 1/89 through 8/89

Figure 4. Top five systems by MMH/FH to repair.

With the cooperation of Colonel David K. Wright, F-16 System Program Manager (SPM), Ogden Air Logistics Center, Hill AFB, Utah, the sponsors of the SIDAC concept launched an investigation into alternative technologies to resolve this problem and demonstrate how the services of SIDAC could be applied. The specific objectives of this study were to:

(1) Compare the logistics impacts of the existing F-16 battery system to a new battery system proposed by Battelle Memorial Institute, using the R&M 2000 goals as measures of merit.

(2) Evaluate the impact on sortie generation capability.

(3) Provide analytical tools to the F-16 SPM so additional organic analyses could be performed.

Before proceeding into a discussion of the results, a brief review of the model used to perform the analysis is in order. However, this should not be considered an endorsement for one contractor's product over another, but merely an illustration of the SIDAC concept. In this case, the model used to perform the analysis for the F-16 was developed by the Dynamic Research Corporation under contract to the WRDC and is referred to as the Logistics Assessment Methodology Prototype (LAMP) Model which runs on a standard USAF Z-248. This specific model was developed in response to the Air Force's R&M 2000 program and integrates six accepted DOD models in such a manner as to display the results in terms of the five Air Force R&M 2000 goals (combat capability, vulnerability of the combat support structure, mobility, manpower, and cost). The relationship between the R&M 2000 goals and the six DOD models used in the LAMP program is illustrated in Figure 5.[12]

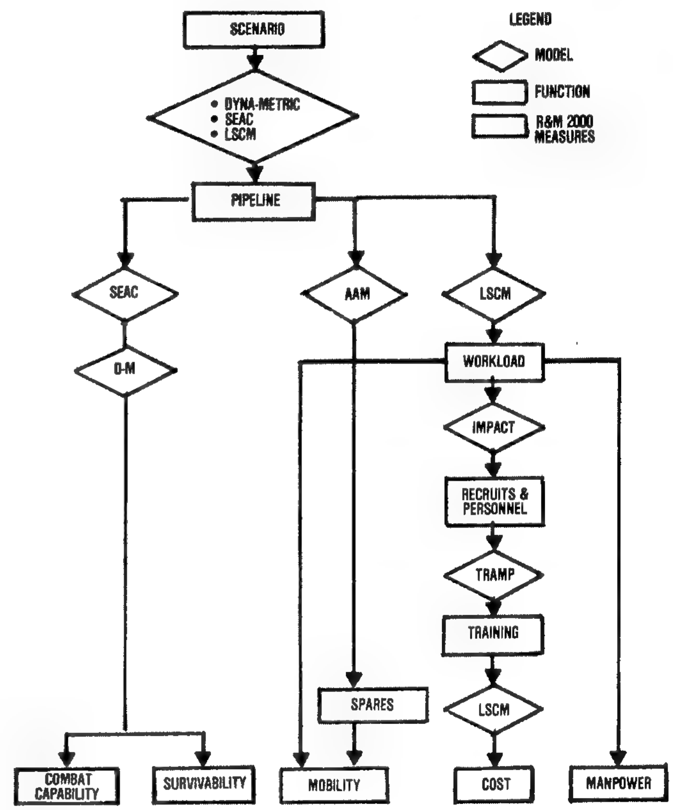


Figure 5. LAMP algorithm interaction.

Using this approach, it is possible for the logistician or other managers to perform various types of analyses. In this case, once the data on both the existing and the new system was collected and entered into the model, the analysis began by identifying exactly which components within the F-16 battery system were failing. Figure 6, an output product from the LAMP program, shows that over a 30-day period, on average, the USAF would be short a substantial number of batteries (WUC 42GAA) and probably would be unable to satisfy the required number of sorties under such a scenario.[13]

Having identified the item most in need of improvement in this system, a typical next step might involve performing a series of "what ifs" to investigate the impact of increases in reliability on the unit's ability to generate sorties. Figure 7 illustrates an output graph from such an exercise. Of course, given the funding

constraints in which we all operate, another critical question which must always be addressed is the impact of such changes in the life cycle cost of the system. Given the increased cost to achieve incremental increases in reliability, the tradeoffs between MTBF and life cycle cost can be readily investigated, as displayed in Figure 8.

To an AFSC Program Manager, AFLC System Program Manager, or decision maker anywhere throughout the system, a breakdown of cost is always important; and, using this concept, such breakdowns can be readily illustrated as indicated in Figures 9 and 10. Figure 9 is a breakdown of the proposed battery system by acquisition dollars, research and development (R&D) costs, and operations and support (O&S) costs, while Figure 10 illustrates a further breakdown of the O&S costs into their respective integrated logistics support (ILS) elements.

In Figure 11, the original battery (#2 in the graph) is compared to the replacement battery in terms of its ability to satisfy operational requirements. As clearly illustrated in this figure, the new battery is capable of satisfying 100% of anticipated requirements. Finally, in Figure 12, the two systems are directly compared in terms of their impact on the five USAF R&M 2000 goals, where the existing system is presented as the 100% baseline.

Using the measures of merit indicated, the new system clearly outperforms the existing system in four of the five categories

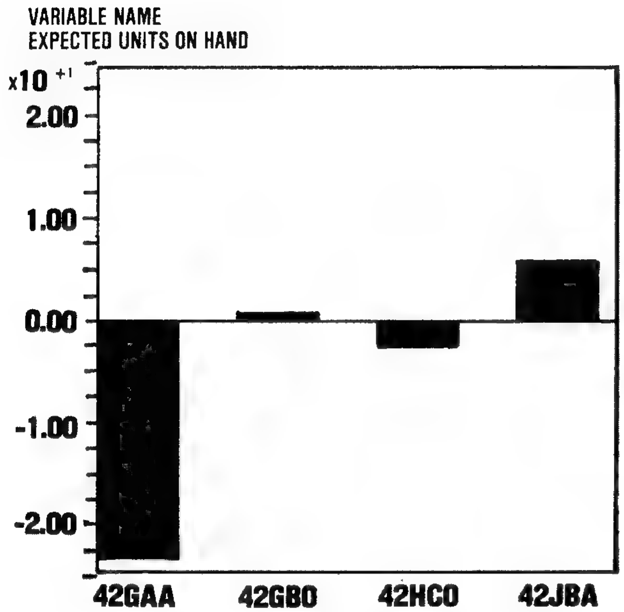


Figure 6. Average expected number of F-16 battery components on-hand for 30-day period.

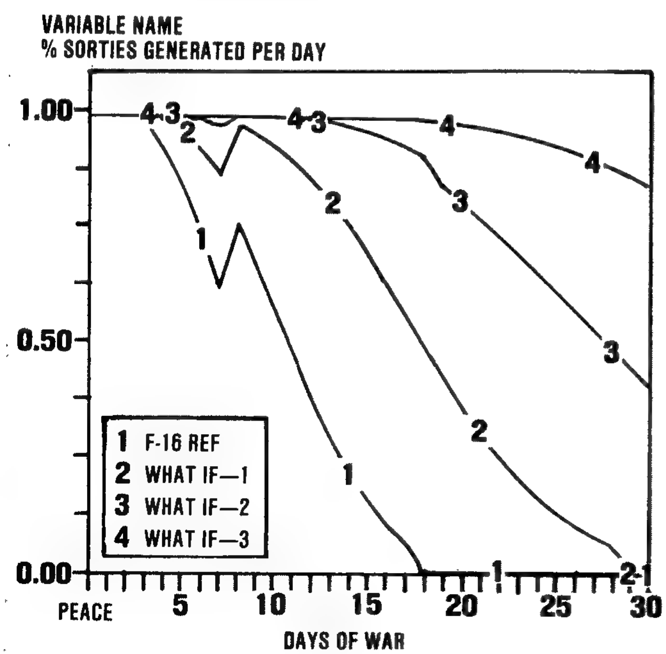


Figure 7. F-16 sortie generation "what-ifs."

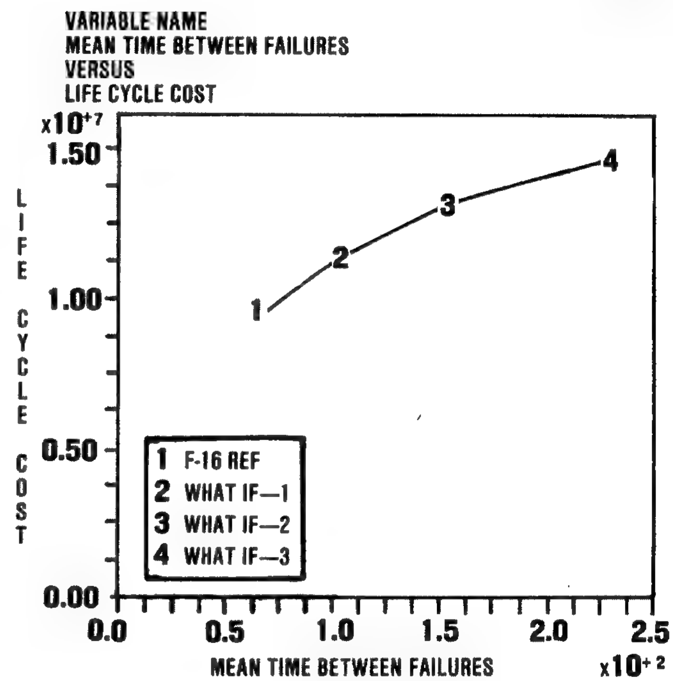


Figure 8. F-16 life cycle cost "what-ifs."

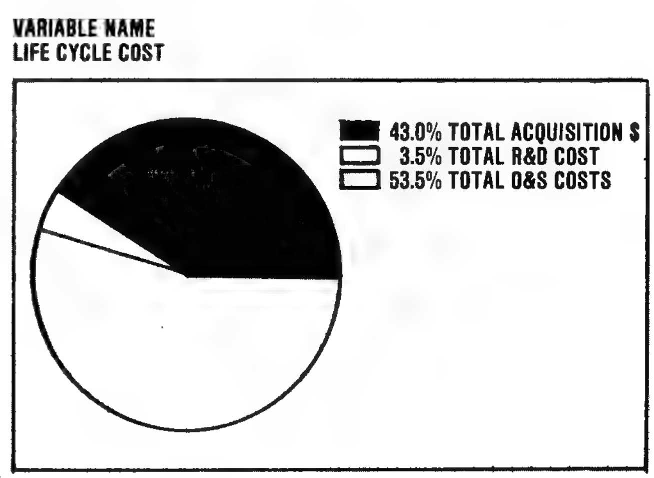


Figure 9. Breakdown of major program costs.

noted; and the results indicate the F-16 aircraft should be modified with the proposed new battery. More specifically, the results of the F-16 Battery Replacement Analysis demonstrated there would be a significant improvement in supportability if the F-16 were modified with the new battery. Also, the new battery would result in increased combat capability while simultaneously decreasing the vulnerability of the combat support structure; manpower and mobility requirements; and, finally, life cycle costs. This analysis also revealed that a two-level maintenance concept for the new battery would be most cost effective. From a broader view, this study also demonstrated how access to tools, such as the LAMP Model, can be reasonably applied to solve real Air Force problems through an organization such as SIDAC.

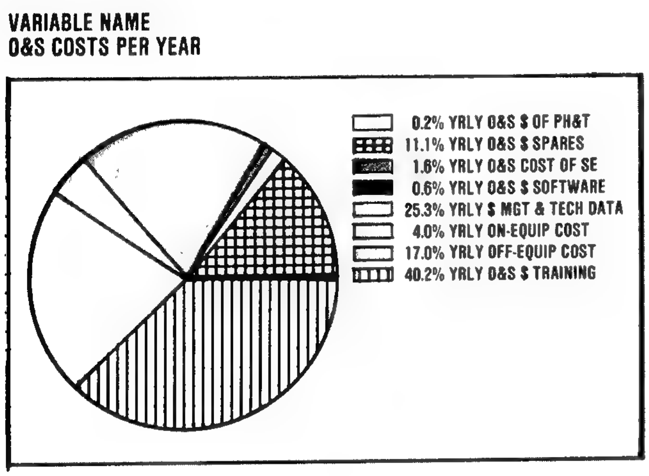


Figure 10. Breakdown of O&S costs.

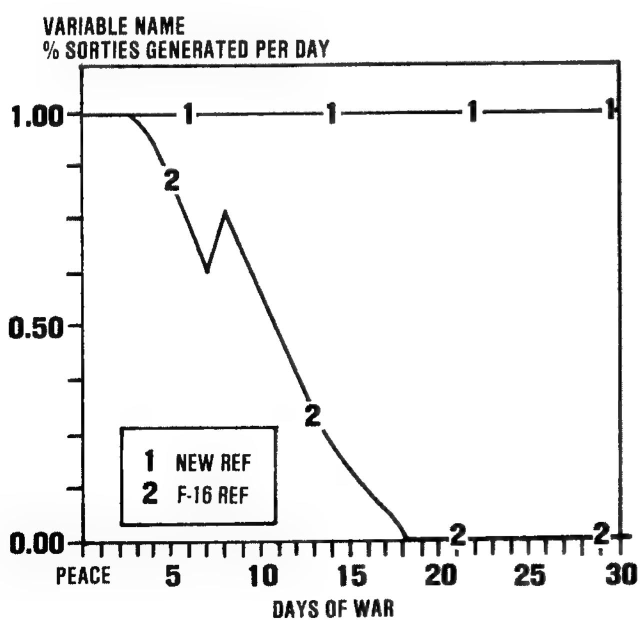


Figure 11. Sortie generations: old vs new.

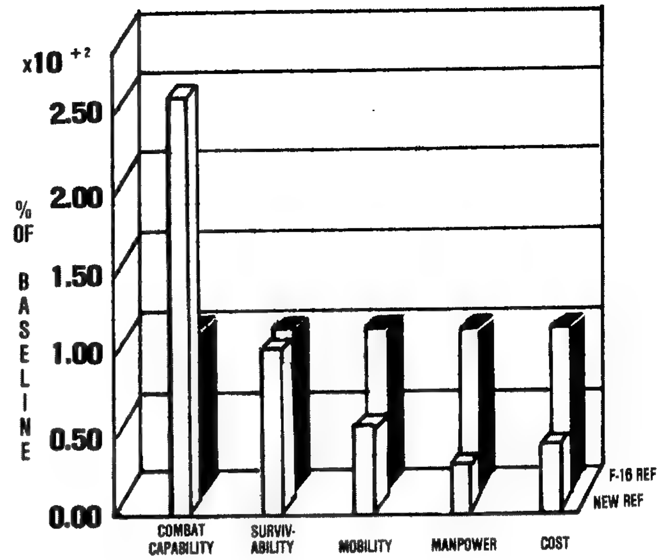


Figure 12. R&M 2000 comparisons.

Applying SIDAC: An Educator's View

For many years the academic community has frequently spoken of a "basket of tools" where the appropriate tool is selected and applied to the specific task at hand. The SIDAC concept, as illustrated by the F-16 example, demonstrates how, as a result of today's hardware and software technology, we are now at the verge of making the basket of tools concept a reality. What is really needed, however, is a "tool for the tools" as suggested in a recent RAND report on a similar concept;[14] and the establishment of a SIDAC would certainly provide an excellent vehicle to assist in achieving that objective.

Like many of our practicing colleagues, educators are also being pressured to produce better products with less time and fewer resources; and, once again, today's technology can be both a blessing and a curse for the educator or research oriented scholar. Using the aforementioned structure as a framework, however, it would be extremely useful to access a menu which would include self-paced instructions and examples of how to apply certain analytical techniques to reinforce information presented in the classroom. Through modems or hard-wired systems, students could have access to such techniques and models as well as additional SIDAC services.

In addition to teaching, the AFIT faculty is also charged with performing research and consulting to meet Air Force and DOD needs. Within the School of Systems and Logistics, for example, over 150 master's theses are written every year. Many of these studies rely upon data from Air Force information systems which are then analyzed using the appropriate methodology. By extracting information from AFLC's data systems, for example, and applying the appropriate SIDAC resident model to examine specific problems, one can readily understand how the services of SIDAC could be used to further enhance AFIT's thesis program and supplement the faculty's ability to perform research and consulting to support DOD needs.

Summary

As described, the SIDAC concept is presently more of a vision than reality—a vision shared by the Air Force Systems Command, Air Force Logistics Command, Air Force Institute of Technology, and other agencies. The models and expertise already exist but are fragmented and scattered among DOD agencies throughout the world. However, the technology is now available to make the vision a reality. At the time of writing, AFSC, AFLC, and the Joint Logistics Commanders have endorsed the SIDAC concept, and the program is now in source selection with a contract award date scheduled for the early part of 1991.

(For more information on the SIDAC concept and plans for implementation, please contact Mr Michael B. Silverman, Executive Manager for the SIDAC Program, or Ms Mary C. Potter, SIDAC Program Manager, at WRDC/TXL, Wright-Patterson AFB OH 45433-6583, AV 785-4331 or (513) 255-4331.

Notes

[1]Schering, Thomas E. Defense Logistics Studies Information Exchange, U.S. Army Logistics Management College, Ft Lee, Virginia, telephone interview, 30 August 1989.

[2]Haverly, Richard C., Smith, Douglas W., and Steele, Deborah P. *Logistics Software*, Stamford, Connecticut, Arthur Anderson and Company, 1988.

[3]Richards, Tyde, Chignell, Mark H., and Lacy, Richard M. "Integrated Hypermedia: Bridging the Missing Links," *Academic Computing*, January 1990, p. 24.

[4]*Supportability Investment Decision Analysis Center (SIDAC) Final Report.* Technical report prepared for Air Force Systems Command, Wright Research and Development Center, by Dynamics Research Corporation, 30 September 1989, p. 2-2.

[5]SIDAC Newsletter, Vol 1, No 2, February 1989, p. 1.

[6]SIDAC Final Report, pp. 3-1 through 3-8.

[7]Ibid., p. 5-2.

[8]Ibid., p. 5-12.

[9]Ibid., p. 6-6.

[10]Hales, Kenneth M. and Reske, Frederick M. "Assessing Supportability Through Innovative Dyna-METRIC Spares Assessments," *Air Force Journal of Logistics*, Fall 1989, pp. 33-40.

[11]*Supportability Case Study: Proposed F-16 Battery Replacement.* Technical report prepared for Air Force Systems Command, Wright Research and Development Center, by Dynamics Research Corporation, 3 November 1989, p. 6.

[12]*LAWS R&M 2000 User's Guide.* Prepared for Air Force Systems Command, Wright Research and Development Center, by Dynamics Research Corporation, 3 November 1989, pp. 17-18.

[13]It should be noted that information presented in this article is based upon a hypothetical but potentially realistic operational scenario. All numbers used in this model can be varied to enable decision makers to readily assess various alternatives such as changes in reliability, maintainability, number of personnel, weight, volume, cost, pipeline times, number and length of sorties per day, cost, and other variables, depending upon the system or components being evaluated.

[14]Bennett, J. Bart. *A Conceptual Design for the Model Integration and Management System*, The Rand Corporation, N-2645-RC, April 1989. p. 3.

(NOTE: Since Col Materna wrote this article, he has retired and is presently a Manager at NCR World Headquarters, Dayton, Ohio.)

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Any way you want to look at it, the Exchange is a time-saving, money-saving way to get the logistics information you may need or want for your research or studies. All you need is your dial tone to open this treasure chest of logistics information.

ARMY LOGISTICIAN, Nov-Dec 1990

Fighter Design From the Soviet Perspective

Richard D. Ward
General Dynamics Corporation
Fort Worth Division
Fort Worth, Texas 76101

EDITOR'S NOTE: It is interesting to note that, as OPERATION DESERT STORM unfolds, the Iraqi Air Force appears to be following the classic Soviet tactics of dispersal and stand down as discussed in Part I of Mr. Ward's article.

(Part I of this article was published in our Fall 1990 issue.)

Part II

Design Criteria

A. OPERABILITY - The design of weapons to conform to the overall warfighting infrastructure.

B. RELIABILITY - The design of equipment to perform required functions dependably for a postulated combat life.

C. MAINTAINABILITY - The combat servicing and repair characteristics of weapons necessary to minimize combat requirements for test equipment, trained personnel, and spares.

D. PRODUCIBILITY - The design of equipment to be more easily manufactured in both peacetime and wartime environments.

As stated over and over again, the Soviet warfighting approach emphasizing readiness and sustainability dictates that combat and support systems must be available to the commander for a specified combat life. This combat-life requirement establishes the aircraft design criteria.

A. OPERABILITY

Weapons operability, in the Soviet context, is the measure of the balance between advance technology and reliability. On one hand, there is the choice of weapons that employ all the high-risk, advanced technologies available, which need complex support systems and training; but, if on the other hand the military planners opt for older and familiar low-risk systems, the failure to use advanced technologies will deny military forces increased firepower. In the attempt to achieve the optimum balance of technology application, Soviet military planners have analyzed operational effectiveness by methodically evaluating performance against readiness. As a result of this compromising approach, Soviet military equipment appears to be markedly inferior when compared to its Western counterparts. In fact, one of the principal differences between Soviet and Western weapons is that the Soviet weapons are designed according to the rigid combat readiness demands requiring short-term high combat-life reliability and not maximum performance with long-term, peacetime durability.

Criteria for designing weapons to operate in combat must be determined by a realistic view of the wartime environment. The Soviets believe that, under the intensity of combat, the operator's ability to make anything but the simplest maintenance decisions will be greatly hindered. If ground crew members must function while under attack, at night, in snow, and wearing chemical protection gear, operating efficiency will be inherently minimal. Soviet planners require that weapons must be designed to be operated and maintained effectively in such situations. The extent of the attention given wartime operability of Soviet aircraft is shown by the fact that many crew chiefs for Soviet-built fighters in Third World air forces are unable to read, yet frequently maintain higher sortie rates than companion Western-built aircraft needing educated crews. Obviously, Soviet crew chiefs can read, but the necessity to read such items as maintenance manuals during the heat of combat should be the exception.

To ensure that each new aircraft model is compatible with the wartime operability requirement, the Ministry of Aircraft Industry (MAP), in cooperation with the responsible prototype design bureau (OKB), builds approximately 50 preproduction aircraft. These aircraft are sent to a typical operating base for a protracted operational test and evaluation (OT&E) stage, where the air base crews operate and maintain the aircraft under the close observation of MAP and OKB engineers. Following the OT&E stage, the aircraft, some air base crews, and the engineers return to the factory and correct problems identified during the test. The aircraft design is correspondingly modified and then goes into production.

B. RELIABILITY

Reliability, in Soviet terms, is the measure of increasing warfighting availability and survivability while decreasing support requirements. The Soviet goal is for combat equipment that does not have a fabrication or wear-out type failure for its postulated combat life. Reliability does not mean incorporating several levels of redundancy or adding extensive self-test systems. The Soviets design-in redundancy and self-testing, but only to a limited extent. They also employ the universal methods to enhance reliability of quality assurance, failure history analysis, selection control, and viability tests. The Soviet reliability requirements, however, rely heavily on two other methods: highly overdesigned critical components and extensive use of parts of established reliability.

By overdesigning parts, many possible manufacturing faults resulting from low-skilled manpower (such as during wartime) and high production rates are circumvented. For instance, if a panel is designed to be over-strength, then the rivet and spot weld patterns do not have to be precise to be reliable.

By use of parts with proven reliability, such as mature components from older aircraft, the reliability has already been established. Additionally, repairs will be more reliable because the maintenance crews are already trained in the repair of the familiar component, using familiar repair equipment.

C. MAINTAINABILITY

Equipment maintenance in wartime is a procedure the Soviets believe should be avoided, not made easier. Soviet weapon requirements are based on the premise that any maintenance in the combat zone degrades effectiveness because repairs call for additional and valuable maintenance personnel, as well as stores of repair equipment and spare parts. Also, to make the aircraft easily repairable under combat conditions, costly on-board maintenance space must be allocated and numerous structural degrading access doors incorporated. It must be recognized, however, that Soviet weapons are subject to unscheduled maintenance (as are all machines), but in their case extensive

efforts are made to eliminate, but only for the postulated combat life, as much maintenance as possible.

One of the Soviet's principal approaches to eliminating wartime maintenance would probably be unacceptable in the West: namely, scrapping combat aircraft and major components requiring more than a few hours to repair. The Soviets believe that replacement from reserve stockpiles is more effective because the time and personnel needed to effect repairs would only hinder austere deployment operations, mobility, and sortie rate. Additionally, they believe most battle-damaged aircraft can only be effectively repaired at major repair depots anyway, which, to the military commander, is the same thing as losing the aircraft. It should be noted that the out-of-order aircraft will be eventually reclaimed by special salvage units, but this will have little effect on the commander's ability to accomplish the immediate mission.

The main drawback of abandoning weapons needing repairs during wartime is the requirement for a large material reserve and special training to reassemble the replacements. But, in the Soviet peacetime support cycle, using replacements from reserve stockpiles is part of their approach to keeping combat equipment in standing-start readiness condition. Therefore, the low level of peacetime aircraft repairs on the air base is conducive to the wartime requirement in which operational units should have to make only limited field maintenance. Coincidentally, if weapons need not be readily field repairable, many complex and costly design features can be avoided, such as repairable parts and access panels.

D. PRODUCIBILITY

To meet Soviet sustainability requirements, the design of combat equipment must be compatible with massive production runs, particularly under wartime conditions. This mandate dictates that the organization of the national economy be compatible with defense production. Accordingly, weapons design must be compatible with the limitations and capabilities of a defense industry structured for wartime production. The designer must balance cost against performance, advanced fabrication processes against available machinery and manpower skills, advanced technologies against production quotas, materials against resources, and complex and widespread manufacturing networks against concentrated wartime production centers. These considerations rely heavily on simplicity of design.

To balance producibility and performance, Soviet planners require that weapons need only be *adequate* to meet a specific mission for a given combat life. This performance adequacy—or limit—allows simpler and cheaper fabrication materials and processes, which, in turn, facilitate massive production runs. One compromise to producibility is that weapons must be producible in a wartime environment by rejecting more efficient and economical industrial networks for concentrated industry centers with less vulnerable transport infrastructure. Hence, a larger percentage of each Soviet aircraft is manufactured at each assembly factory than in the West. In this system, after successful prototypes are approved for production, they must be redesigned to be compatible with the available processes of the plant where production is assigned. Incidentally, operational aircraft being returned for overhaul must be returned to the factory where they were built to be compatible with the tools and machines.

*To meet the design criteria for each new weapon system, Soviet aircraft designers are controlled by rigid operational and fabrication **design constraints**. Their principal approach to meeting these constraints is by limiting additions to new models of advanced technologies and new components. This design conservatism is sustained in the form of design **heredity** and component **commonality**. Developing weapons with adequate performance which still meet the design constraints is accomplished by the cautious balancing of resources and requirements, or **configuration economy**.*

Design Approach

A. DESIGN CONSTRAINTS - The design methods employed to balance combat effectiveness and conservation of resources.

B. HEREDITY - The design approach of developing new systems by direct extrapolation from previous efforts.

C. COMMONALITY - Current design efforts utilizing components of past and concurrent designs.

D. CONFIGURATION ECONOMY - The design approach which ensures equipment compatibility with design criteria by integrating simplicity, evolution, commonality, and fabrication constraints to reduce preproduction development risks.

To meet the readiness criteria, the designer must follow a unique priority of design considerations:

(1) Maintainability under combat conditions.
(2) Supportability at austere sites.
(3) Producibility in a wartime environment.
(4) Cost considerations.
(5) Training for conscript and reservist.
(6) Combat performance.

Although performance is itemized last, it is important to the user. But, the Soviets have judged that the wartime environment is so severe that reliable and simple weapons are the only fighting equipment that have a chance of being available to perform for the duration. The first three Soviet design criteria, therefore, have priority to assure that aircraft can be massively produced, widely deployed, and rapidly employed.

A. DESIGN CONSTRAINTS

Design constraints for the designer are formalized in a series of "handbooks" supplied by applicable research offices of the Ministry of Aircraft Industry. These handbooks itemize the approved aerodynamic shapes, approved materials, and manufacturing processes allowed the designer. With these handbooks, designers have little leeway in design choices making their principal function to apply the handbook standards as efficiently as possible. Therefore, to the Soviet designers, the best design innovation is one that results in the simplest solution to the handbook constraints.

Soviet design constraints are divided into two basic categories: operational constraints and fabrication constraints.

(1) **Operational Constraints** - are those design features incorporated into the aircraft to meet the combat operations and support requirements detailed in the design criteria.

a. Takeoff to Landing

Austere-site-deployment suitability is a primary design consideration for Soviet aircraft causing the designer to stress simplicity, reliability, and ruggedness. For instance, aircraft propulsion systems are designed to eliminate foreign object damage during sod field operations.

To ensure the aircraft can fly from a wider choice of dispersed bases, takeoff and landing should be as short as possible. The Su-27 currently holds the short takeoff and landing (STOL) records, a commensurate capability. Also, the MiG-29 Fulcrum

and Su-27 Flanker are both being tested for STOL operations incorporating ski-jump takeoff ramps. Takeoff ramps allow a dramatic decrease in runway length, therefore increasing operational flexibility. A fully loaded Flanker using a portable ramp setup can be airborne in less than 300 meters, an important capability for operating from damaged runways and remote deployment sites.

b. Landing to Takeoff

Towing the Su-25 Frogfoot and the Su-27 Flanker before and after flight operations is done by attaching a towline from the heavy-duty towbar to the main landing gear to pull the aircraft, and attaching a special steerable fitting to the nose landing gear. In this way, the much stronger main landing gear takes the towing loads while the aircraft nosewheel is steered from the tow truck. For the MiG-23 Flogger and the MiG-29 Fulcrum, the towing system is designed so both towing and steering are with the nose landing gear. An interesting note is that current MIG fighters are the same width, ensuring the same tow and hangar width (Figure 9).

The logistics support of Soviet high-performance combat aircraft during wartime calls for special design considerations. As noted earlier, Soviets only allow very minor repairs to be done by the aircraft ground crews with almost all tasks limited to preflight and postflight activities. This very limited organizational level approach to maintenance results in many significant design characteristics of Soviet aircraft. This feature is feasible because with the short-term, high-reliability systems required of Soviet weapons, frequent repairs would not be needed, consistent with the wartime environment. This maintenance philosophy also permits the use of lower skill level ground crews. Generally, this wartime-oriented method of maintaining aircraft ensures high peacetime readiness and efficient wartime sortie generation.

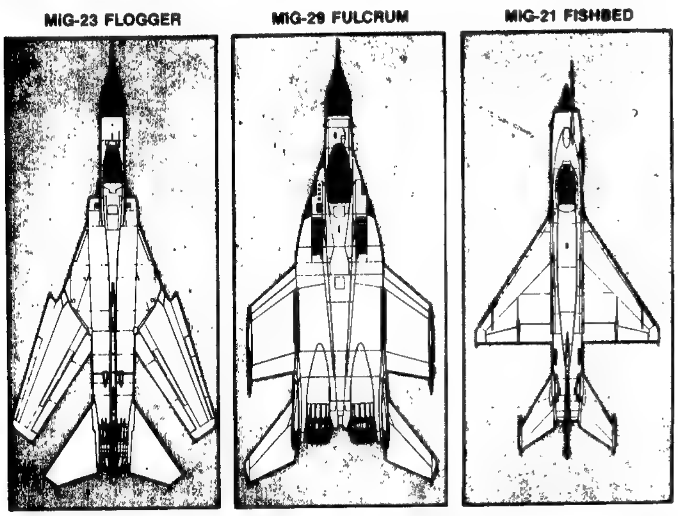

Figure 9. The width of the aircraft is dictated by towing and shelter constraints. The MiG-29 Fulcrum with the currently detachable outer wing panel removed is the same width as its two predecessors, the MiG-21 Fishbed and the MiG-23 Flogger.

To test and warm up on-board systems before each flight, Soviet fighters have power hookups on the left side where the electrical power line from the aircraft support truck can be connected. The hydraulic, avionic, and fuel systems can be readied for flight with this auxiliary power source and the only task required before takeoff is to start the engine.

To not jeopardize the mission, several redundant modes are available to the ground crew for wartime servicing reliability of the current generation aircraft. For instance, refueling backup systems are required on all combat aircraft. The primary method is by single-point pressure refueling through NATO compatible receptacles; the backup is with several gravity feed receptacles. For aircraft that carry external tanks, the tank attachment fuel ports using on-board fuel pumps are also available.

Wartime inspection and repairs are accomplished by dispatching PARM units, as needed, from a regimental repair center to the dispersed base. Inspection is simplified by designing the aircraft so umbilicals for diagnostic data retrieval equipment can be quickly attached without opening large access panels (Figure 10). The unprocessed data is downloaded to the truck-mounted PARM shops for analysis. This approach reduces on-board processors and access time, and eliminates equipment bay exposure. An added advantage to this approach is that the aircraft skin can be designed with fewer access door discontinuities, allowing more efficient and, therefore, lighter-weight structure. Incidentally, this structural continuity permits very efficient composite applications.

Soviet aircraft attrition replacement during wartime is accomplished by replacing the damaged aircraft, or components, from reserve stockpiles. Therefore, a large percentage of all combat aircraft in the air force inventory are in reserve storage. To facilitate this requirement, Soviet frontal aviation aircraft are designed to be compactly stored in a special crate from which they can be quickly removed and assembled. For instance, the disassembled MiG-21 Fishbed is stored in a crate approximately 47 feet long and 10 feet wide (Figure 11). The MiG-23 Flogger

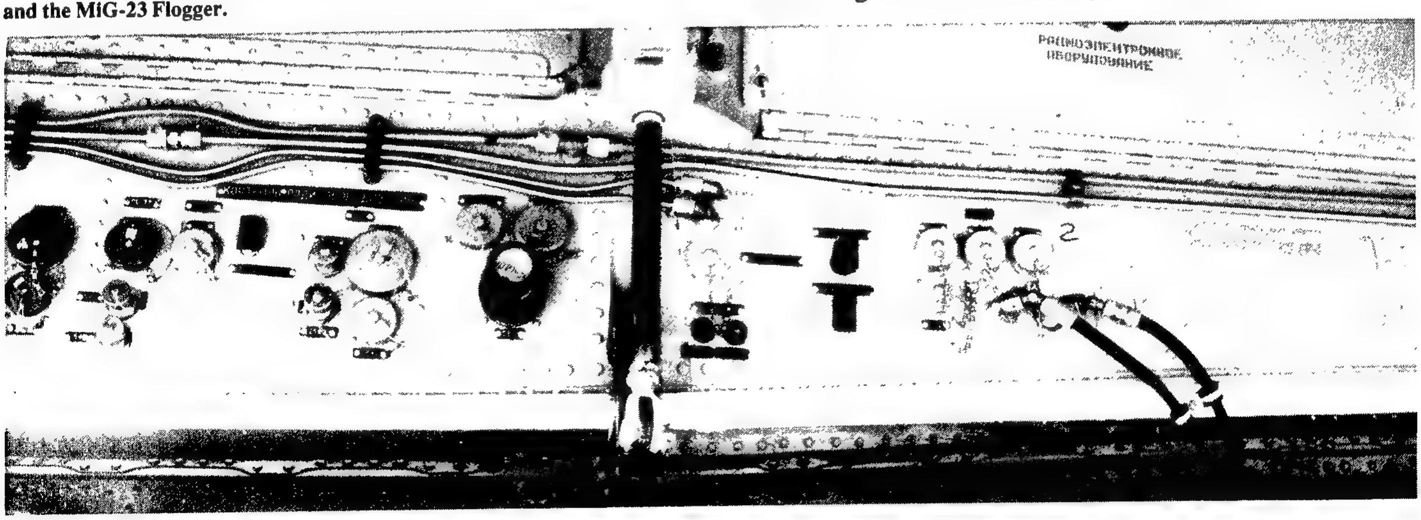

Figure 10. Diagnostic umbilical connectors are concentrated on the right wall of the Su-27 Flanker nose wheel well.

crate had to be larger, about 67 feet by 17 feet, to allow the longer fuselage, and wider for the variable sweep wing carry-through structure. The MiG-23 replacement, the MiG-29, however, was a very different configuration but was required to fit into the same volume (Figure 12). To meet the MiG-23 Flogger size constraint, each wing of the MiG-29 Fulcrum is designed to be disassembled into two parts and the interchangeable, vertical tails are removable. It should also be noted that all the spares necessary until the next overhaul are stored in the crate with the aircraft.

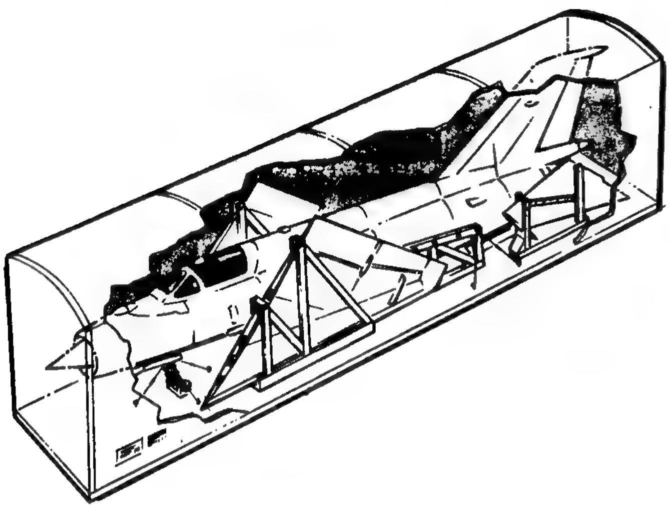

Figure 11. The MiG-21 Fishbed is stored in a sealed shipping crate including all the dollies, fixtures, tech manuals, and tools necessary for assembly. Anticipated spares needed until the next overhaul are also included.

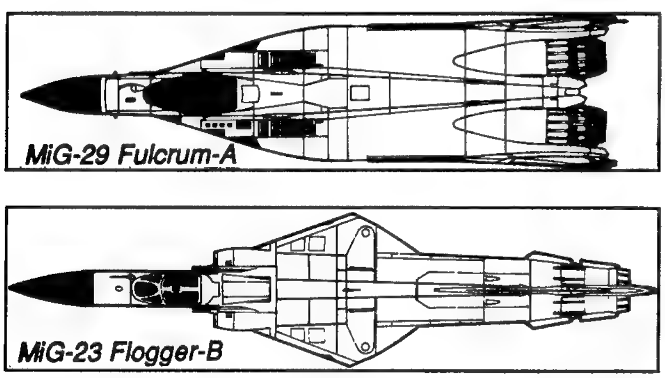

Figure 12. To meet standardized storage requirements, the dissassembled MiG-29 Fulcrum fits in the same volume as its predecessor, the MiG-23 Flogger. In fact, the length constraint on the Fulcrum caused the RD-33 engine afterburner to be less than optimum length, causing extensive development problems.

Disassembly of Soviet aircraft for storage calls for special structural design considerations, such as limiting disassembly attachments to a few simple lugs, three for the MiG-29 wing/fuselage attachment. This approach requires concentrating load paths at these few, very high stress points. The Soviet design solution has been to make the center fuselage box, which carries wing and landing gear loads, out of steel, a nonstrategic metal that is easy to weld and has high bearing strength.

(2) **Fabrication Constraints** - are those design features incorporated into the aircraft configuration compatible with the resources, machines, and manpower available in a wartime industry. Additionally, these constraints must facilitate massive and high-rate production runs necessary to meet peacetime material reserve requirements and prolonged conflict attrition replacement requirements. An example of fabrication optimization is in the design of the horizontal stabilizer of the Mi-26 Halo, the world's largest helicopter. The materials are steel tube spar, plywood ribs, balsa wood leading edge, and canvas skin; therefore, the component is extremely easy to build and very inexpensive. This method of construction was chosen because of the part's location (it receives frequent damage from flying debris); and, with this design, it could be simply and economically replaced.

To ensure simplicity in production, minimum assembly and finishing standards are used—where not critical. Examples of aircraft construction practices on the MiG-29 show that:

- Little emphasis is placed by Soviet designers on tolerances in noncritical areas such as the gaps around access and landing gear doors, flushness of fasteners, and alignment of rivet including continuous and spot weldment patterns.
- Soviet equipment shows the extensive use of welded fittings in combination with numerous castings and forgings to limit complex machining (Figure 13).
- Airframe structures are designed around materials that work at low stresses and are assembled through use of both spot and continuous welding (Figure 14). Western aircraft designers seldom use spot welding because of its limited fatigue life; but, if aircraft are frequently overhauled, weldments can be inspected and replaced in a timely manner. Because of the liberal use of weldments, Soviet aircraft have several nonrepairable parts however; and these are replaced by exchanging entire subassemblies during the frequent overhauls.

Simple designs are inherently more reliable and rugged; for instance, in systems with low parts count. For example, the R-11

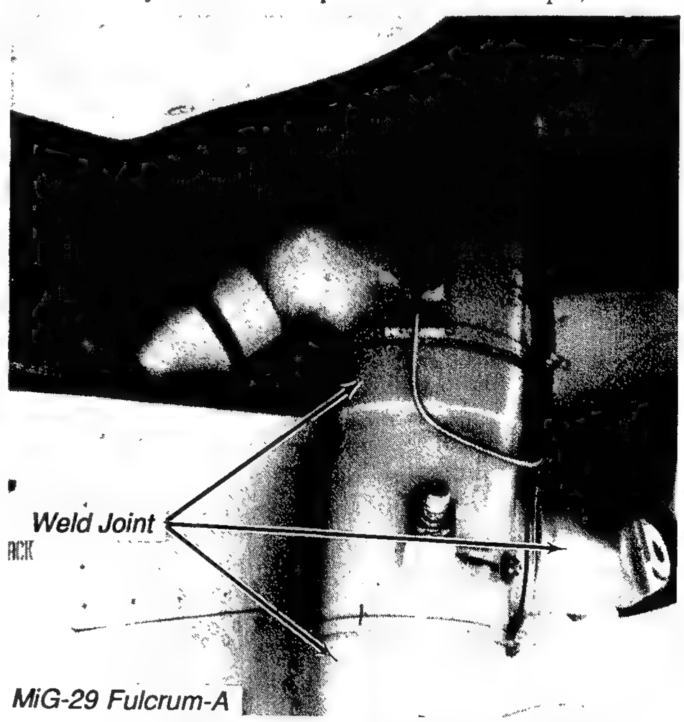

Figure 13. Landing gear struts are typically fabricated of several small welded forgings to facilitate required nonaligned placement of lugs and the trunnion.

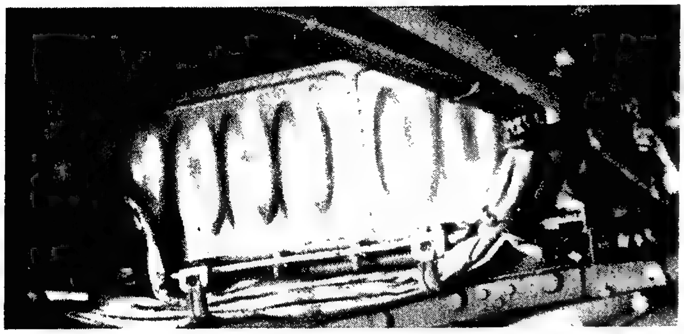

Figure 14. The MiG-29 torque box/fuel tank is a welded steel structure designed to carry concentrated wing loads and landing gear loads.

turbojet engine that powers the MiG-21 Fishbed fighter has a little over 5,000 parts—impressive when compared to the 30,000 parts in the F-4 Phantom's J-79, an engine of the same era and thrust class.

B. HEREDITY AND COMMONALITY

Soviet designers develop each new system by the careful metering of modifications to the previous design. In this way, the Soviet designer can minimize development disruptions by allowing only limited amounts of advanced, and therefore high-risk, technology in any one prototype. Design heredity and component commonality are quite evident in the design history of MiG OKB fighter aircraft. In the MiG family evolution, each design incorporates many design features and components of its predecessors, or even several predecessors. One possible drawback to design heredity is the necessity for the continuity of a single design team to sustain the corporate knowledge. This long-term team continuity has the possibility of causing design stagnation resulting from the continuing restraints of the older designers. This mind-set possibility, however, is seen by the Soviets as less a problem than organizing a new design team bringing only limited corporate knowledge to each new design.

Design commonality is closely related to heredity since the designer applies actual components of concurrent and previous aircraft to current prototypes to reduce new, therefore higher risk, systems per program. This concept can apply to complete aircraft assemblies, such as wings or empennages, or to smaller components such as instruments, pumps, or actuators. The smaller components could actually be considered standard parts; however, Soviet standard parts lists usually are compilations of simple parts such as fasteners, fittings, extrusions, etc.

The classic example of the application of common aircraft assemblies to a new design is with the development of the Su-15 Flagon intermediate-range interceptor in the early 1970s. The Flagon prototype was a marriage of two R13-300 engines from the MiG-21 Fishbed; the wing, horizontal and vertical tails, and canopy from the Su-9/11 Fishpot; and the RP11 (Skip Spin) radar from the Yak-28P Firebar - with the only original development being the fuselage. In the same lineage, the swept wing counterpart to the Su-9/11 Fishpot, the Su-7 Fitter, was improved by adding a variable sweep wing and renamed the Su-7 lG; the aircraft went to production as the Su-17/20/22 Fitter-C/H.

Interestingly, with each new generation of aircraft, Soviet designers are relying less on heredity and commonality as principal design tools. Soviet aircraft designers are actually increasing the percentage of new technologies and components introduced into each new model. The current generation of fighters, including the Su-27 Flanker and MiG-29 Fulcrum, incorporate new airframes, engines, guns, radars, and missiles, the first time these systems have been concurrently developed for new aircraft models—definitely a higher risk, nonheredity approach.

Heredity, however, still influences Soviet aircraft design, but in more subtle forms:

- The MiG OKB incorporates several welded internal structural assemblies while Sukhoi prefers riveted assemblies.
- MiG prefers constant radius canopy layout; Sukhoi, the teardrop shape.
- MiG prefers wing/fuselage attachment lugs to be outside the wing and fuselage lines; Sukhoi, inside.
- MiG prefers external surfaces to be lofted with straight-line elements and circles and straight lines in cross section; Sukhoi employs more complex surface shapes.

In commonality, as with heredity, an increasing percentage of major components are unique to each design; however, small parts commonality is still widespread. The common use of the same components is most evident to the Western observer in Soviet cockpit instruments. The Sirena II radar warning system in the MiG-29 Fulcrum, the Su-25 Frogfoot, and the Su-27 Flanker is the same one developed for the 1950's vintage MiG-21 Fishbed.

C. CONFIGURATION ECONOMY

To ensure that production meets national objectives and assets, the Soviet designer must balance performance against producibility. Whereas heredity and commonality are design methods employed to reduce development risks before production, the performance/production balance is the measure of program cost effectiveness—configuration economy. One example of design economy is found in the Soviet approach to temperature-related, parameter-variations control in solid-state equipment. The accepted method is to design circuits that are self-compensating. The Soviets chose to provide microclimate enclosures in which the component environment was protected from temperature and humidity variations with on-board miniature air-conditioning/heating systems. In this way, a more complex, higher-risk circuit design was avoided by incorporating a mechanical solution.

Important elements of configuration economy are in the judicious application of **standardization**, **modularity**, and **redundancy**.

(1) Standardization - ensures the minimum variety of equipment, optimizes the ability to interchange assemblies and components, and reduces training and logistics requirements. Standardization involves the use of approved parts lists of components, assemblies, and subsections wherever possible. An example of materials standardization is the way the Soviets chose extrusions for their designs. The available shapes and sizes of the standard extrusions to the Soviet designer are very limited when compared to the variety available in the West. The ones available are especially configured to overcome that apparent shortcoming. Built-up structures are reduced by incorporating skins and stringers, extruded as one part, throughout the aircraft as wing and tail skins, access panels, and fuselage skins.

Another special feature of the Soviet extrusion design is the cross-sectional geometry of several beams to facilitate nesting with other extrusions or even rolled steel bands. In this way, designers have the choice of either a standard extrusion to meet a particular structural need; or, if the strength of the available sections is not optimum, then they can build up a near-optimum part by bonding nested sections. In fact, designers have the

choice of nesting such materials as an aluminum extrusion with a steel band. What would be a problem of attaching dissimilar metals with the resultant corrosion is not of great concern to designers because they are designing a relatively short-lived weapon; and, even if a problem develops, it can be corrected during the frequent overhauls.

(2) Modularity - quantifies the size and complexity of nonrepairable components. In the Soviet context, modularity eliminates air base level type repairs and ensures low parts count. For instance, with the Su-27 Flanker engine, damaged modules can be replaced in the field without replacing the whole engine. The Soviet military press reported that, in one air defense unit, a modular low-pressure compressor had been replaced at the regimental (intermediate/base) level. On previous models, the complete engine would have to be removed, crated, and sent to a repair depot. The replacement would have to be drawn from the material reserves.

An added design feature to meet the austere repair environment of the dispersed air base is that component definition is based on failure frequency. In the Soviet jet engines, the afterburner component can be removed while the turbine component is still in the aircraft. In this way that part of the engine which requires over 50% of all repairs—the afterburner—can be removed and replaced in the field without having to disconnect the fuel, electrical, or hydraulic lines. With the failure-priority design approach, field-level repairs are greatly simplified and expedited. The design approach is especially effective in the repair of electrical, electronic, and hydraulic systems components.

(3) Redundancy - is usually defined as the provision of duplicate, backup, or equivalent systems or components to improve survivability, availability, and operability. In Soviet terms, redundancy is defined as systems designed to meet required tasks, not to optimum performance. In other words, equipment degradation, not failure, is the primary design for redundancy consideration. In avionics, circuits are designed to degrade before failure. This approach calls for frequent inspection and calibration, but fewer backup systems are required. This same approach is also applied to mechanical systems with the overdesign of all critical components to reduce redundant and emergency systems. In mechanical systems, redundancy calls for very simple backup systems for survivability and inflated margins of safety in the primary systems for reliability.

*The Soviet designers' mandate is to ensure **simplicity** in layout, **simplicity** in production, **simplicity** in operations, and **simplicity** in support. In other words, the designer must satisfy production constraints and operational requirements with minimum complexity. **Simplicity** is found in all aspects of Soviet weapons acquisition and operation because Soviet military planners believe that, to be effective, weapons must first be **simple**. **Simple** systems are inherently lower risk to develop, less costly to manufacture, and easier for conscripts to service and repair, and operators to use.*

Conclusions

The foundation of Soviet weapons acquisition is a comprehensive and dynamic military doctrine that defines how future wars must be fought to be won and how the nation's civilian and military sectors must be structured and prepared in the eventuality of such a war. Soviet military doctrine, therefore, is the strongest influence on the design characteristics of Soviet weapons, because it stresses that future battles will be intensive and probably prolonged, with very high attrition rates needing a steady flow of replacements. Consequently, Soviet planners require that reliable weapons be quickly available in great numbers while being effectively operated and maintained by conscripts in the extreme environment of war. Consequently, in peacetime, the Soviets maintain a unique form of standing-start readiness with which they are able, at the outset of a conflict, to immediately deploy operational aviation units to, and employ from, austere dispersal bases.

To meet doctrinal requirements, Soviet aircraft are designed for a highly reliable, predetermined (though relatively short), combat life to greatly reduce wartime maintenance on austere deployment bases. Some quarters have questioned the viability of this dispersal concept because of the apparent support complexity of modern weapons; however, Soviet aircraft and their support systems have always been designed with this capability. The question must, therefore, be in the premises held by the questioners. Their problem may possibly be in demanding "mirror images" and ignoring the extreme vulnerability of all fixed basing.

*Soviet military thinkers have determined that, to be effective, weapons must be available in **massive numbers** (in operation and in reserves) and be **highly supportable and survivable** in a wartime environment. Additionally, the Soviets have concluded that while weapons need only be adequate for a given mission, they should be **highly reliable** for their postulated combat life.*

References

This paper is based primarily on personal contacts with several Soviet designers, pilots, and technicians, including close inspection of several of their current military and civilian aircraft. Not only did the Soviets readily furnish extensive information on their aviation industry but they also supplied confirmation of several earlier postulated design and operational features of Soviet aircraft.

Several published sources were also used in the research for this paper, including some of mine. The following are several of the more useful.

Books

Aviaexport, *Aviation Metallurgy of the USSR.*
Baxter, W. P. *The Soviet Way of Warfare*, Brassey.
Eyermann, K. H. MiG *Flugzeuge*, Transpress (GDR).
Glaglev, A. N. *Construction of the Aircraft.*
Handbook for the Aviation Rear Specialist.
Hemsley, John, *Soviet Troop Control*, Brassey.
Matveyenko, A. M. *Airfield Braking System of Aircraft, Moscow Press.*
Soviet Military Encyclopedia.
Taylor, John W. R. *Jane's All the World's Aircraft*, Jane's Publishing.
US Army FM100-2-2.
Vigor, P. H., *Soviet Blitzkrieg Theory*, St. Martin's Press.

Reports and Papers

Bodansky, Yossef. *The Soviet Threat to NATO Air Bases*, General Dynamics, 1989.
Brower, K. S. and Kehoe, J. W. *US and Soviet Weapons Systems Design Practices*, International Defense Review 6/1982.
Director A/S Studies, Kirkland AFB, *Strike Option Comparison Study*, ASCMD/SA.
Lowy, S. H. *Impact of Soviet Logistics Concerns on Aircraft and Gas Turbine Design*, Center for Strategic Technology.
Savkin, V. Ye. *Basic Principles of Operational Arts and Tactics* (USAF).
Soviet Army Studies Office, *The Soviet Conduct of War*, Fort Leavenworth, US Army.

Magazines

Air Force Magazine, Aviatsia i Kosmonautika (Soviet Air Force Magazine), *International Defense Review, Jane's Defense Weekly, Lettecvi i Kosmonautika* (Czechoslovakian Air Force), *Military Logistics Forum, Soviet Military Review, Tyl i Snapzheniye* (Soviet Military Logistics), *Tekhnika i Vooruzheniye, Vozdushny Transport.*

AFIT *The Doorway to Logistics Success*

A key component of the AFIT Graduate Systems and Logistics Programs is the research efforts involved in the master's theses that all students complete. Many of these efforts are sponsored by agencies throughout DOD and the USAF. In the last issue, we highlighted those theses completed in September 1990 that received awards as superior research efforts. Here we highlight several additional theses that may be of general interest to logisticians. Each of these may be acquired through DTIC.

Proposals for AFIT thesis research topics are always welcome. We want to support the logistics community at large. The thesis effort is an excellent mechanism to acquire quality answers to tough problems. If you have ideas, please contact Lt Col Larry Emmelhainz, AFIT/LSC, AUTOVON 785-2061.

TITLE: *The Relationship of Civil Engineering's Emergency Airfield Repair Operations and Tactical Aircraft Design and Development*

AUTHOR: Captain Peter C. Bahm

This thesis examines the relationship of Civil Engineering's emergency airfield repair operations and tactical aircraft design and development. This relationship is important because it probably will impact the outcome of future conflicts involving the USAF. The thesis discusses air base operability (ABO) and how both Civil Engineering (CE) capabilities and aircraft design/capability affect ABO. Also addressed are the possible problems caused by lack of CE influence on aircraft design. Next, research findings and data on the requirements, capabilities, and limitations of CE to repair airfield operating surfaces under emergency wartime conditions are presented and analyzed. This is followed by a presentation and analysis of research findings and data on tactical aircraft design and development, specifically with respect to airfield operating characteristics, requirements, and capabilities. One research objective is to answer the question: Do Air Force Civil Engineering's emergency airfield operating surface repair capabilities and limitations adequately influence aircraft design? Based on the research conducted, the researcher concludes that the answer is "no." Other conclusions are also presented, and some issues are left for further research.

TITLE: *An Assessment of Cost Factors for the Alternatives to Intermediate Maintenance Concept for the Tactical Air Command*

AUTHOR: Major Andrew E. Busch

This thesis assesses cost factors associated with consolidating intermediate level avionics maintenance. The research scenario hypothesizes that CONUS-based F-16 intermediate level avionics repair would be centralized into two consolidated intermediate repair facilities (CIRFs). The thesis seeks to identify the significant changes required in the F-16 logistics support structure by examining the ten integrated logistics support elements as listed in AFR 800-8, *Integrated Logistics Support (ILS) Program*. The literature review examines six studies dealing with the consolidated maintenance concept. The Delphi process solicited the opinions of a panel of logistics experts. The results of the Delphi process were analyzed for agreement on the cost factors associated with consolidating maintenance activities. This thesis concludes that the manpower, supply, and facilities elements would experience the greatest change under a CIRF concept. Moderate cost impact is expected for the training, support equipment, transportation, and computer resources elements. Very little cost impact is expected for the maintenance planning, technical data, and design interface elements.

TITLE: *An Air Base Vulnerability Assessment Analysis Tool for U.S. Air Force War Planners Volume I: Development and User's Manual*

AUTHOR: Captain Richard M. Cockley

This study improves the pre- and post-processor BasePlot before distributing it to experienced air base operability (ABO) analysts and planners. Volume I contains four chapters and an appendix. Chapter I introduces the general issue; states the specific problem and investigative questions; provides background on current ABO issues, history and capability of TSAR and TSARINA, BasePlot's capabilities; and discusses current philosophies of documentation development. Chapter II describes software modification and testing, documentation, user testing, validation, and implementation. Chapter III describes the design, development, and outcome of the modified and enhanced BasePlot. Chapter III also provides an analysis of the pre- and post-processor BasePlot with respect to the goal of creating an efficient software package. Chapter IV describes the results of BasePlot's application and its strengths and weaknesses. This chapter also provides recommendations for follow-on research. The Appendix is BasePlot's User's Manual which documents BasePlot's operations and provides examples of how to use the software package.

TITLE: *Development of a Prototype Decision Support System to Manage the Air Force Alternative Care Program*

AUTHOR: Captain Steven H. Flowers

This research demonstrates the feasibility of developing a decision support system (DSS) for managing the Air Force Alternative Care Program (ACP). A prototype DSS, Alternative Care Assistant, is developed to demonstrate the potential for automating the current manual systems. First, the ACP process is thoroughly examined through the analysis of several data sources. Next, a flow diagram with a supporting narrative is prepared as an information requirements analysis. Accuracy was verified by 11 representatives from different USAF MAJCOMs. Finally, the Alternative Care Assistant was developed using Clipper and was field tested at USAF Medical Center Scott, Scott AFB, Illinois. The prototype DSS has a user-friendly interface and the capability to perform all the ACP's clerical tasks and some managerial tasks such as breakeven analysis. Databases for Common Procedure Terminology (CPT) codes and allowable costs are included in the prototype. These databases were extracted from the Office of Civilian Health and Medical Programs of the Uniformed Services. This prototype operates on any IBM compatible microcomputer with a hard disk drive and MS-DOS Version 3.2 or above.

TITLE: *A Survey of Contractors' Perceptions of Current Barriers to Contracting with the Department of Defense and the Potential Benefits of the Adoption of Commercial Style Acquisition Methods*

AUTHOR: *Eleanor G. Holland*

This study investigates the potential benefits of adopting commercial style contracting methods for the acquisition of commercial items by DOD. Also analyzed are contractors' opinions about possible barriers to contracting with DOD. A literature review indicates that many experts agree that current methods are too complex and that today's environment would welcome development of a pilot program in commercial style contracting. A survey was administered to approximately 400 contractors in the electronics industry. The results indicate that electronics contractors believe commercial style contracting methods would reduce the cost of supplies, decrease delivery times, and increase the number of firms willing to do business with DOD. As a result of these findings, it is recommended that DOD pursue commercial style contracting for commercial items and that a pilot program be developed at the Defense Electronics Supply Center to test this concept. Further data analysis indicates that certain government policies or characteristics discourage participation by contractors in the DOD contracting arena. Based on these findings, it is recommended that barriers to contracting be reduced.

Historical Background

Beginning in 1945, when the first atomic bomb reduced the Japanese industrial city of Hiroshima to a burned-out cinder, and persisting until the 1989 smashing of the Berlin Wall and the freeing of Eastern Europe, a tenacious Cold War between the United States and the Soviet Union had threatened to engulf the world in flames. Fueled by mutual fears and common mistrust over differing world views, the conflict was often waged by proxy, relying on distant disputes and foreign civil wars for its battlefields and its soldiers. But because of the potential worldwide destruction, nose-to-nose confrontations between the two superpowers never emerged. Instead, like mighty rooks and bishops on a huge and teetering chessboard, both countries shifted their military weight to balance world power between themselves and among their respective allies, all to prevent the unthinkable: a thermonuclear war.

As a fortunate consequence, these global gambits usually ended in tactical stalemates, ones that left in their wake a relative though shaky truce. But sometimes, festering grudge matches did erupt between American confederates and their Russian counterparts to threaten that peace. Reminiscent of two older brothers protecting their smaller, scrappy siblings, the primary rivals showed up with arms and supplies to ensure that one belligerent did not outmuscle the other and tip the feeble balance. And, in truth, both nations were ever-vigilant, lest they themselves were drawn into the fray as main contenders. But in 1973, one such contest nearly brought US and Soviet military interventionists to the mat: the Yom Kippur War. As the current war in the Persian Gulf now promises to once again test both the patience as well as the sons and daughters of the American people, so too does it challenge the prowess of Air Force logistics. A look back at the role played by the Air Force Logistics Command during the 1973 Yom Kippur War may well provide a few lessons for the supply of modern-day American air defenses in the Middle East.

Also known as the Arab-Israeli War, the 1973 clash was the fourth in a chain of collisions between Arab and Israeli troops since Israel first declared its independence from the British protectorate of Palestine on 14 May 1948 and was subsequently reorganized by the United Nations as a separate Jewish state. Arab Palestine ceased to exist geographically as a result of the partition, replaced by Israel in the west and Jordan (formerly Transjordan) to the east. In 1956, and again in 1967, ongoing hostilities sparked by Arab-Israeli border disputes continued to pockmark the Middle Eastern landscape. On 6 October 1973, Syria and Egypt, in a concerted effort to retrieve ground lost to the Israelis during the 1967 Six-Day War, simultaneously struck the Jewish state on two fronts: the Golan Heights in the northeast and the Sinai Peninsula to the west. Before long, 11 other Middle Eastern powers, most notably those at the spigots of precious oil flows to the West, lined the edges of the fray and brandished promises to cut petroleum supplies to the United States unless the Israelis met Arab demands. Later, the Mideastern oil cartel established in 1960 to regulate world crude oil prices, known as the Organization of Oil Exporting Countries (OPEC), would indeed punish the United States for its pro-Israel involvement by imposing a six-month long oil embargo that resulted in long gas lines, short tempers, and high fuel prices at home.

The Arab surprise attack moved alarmed American and Soviet officials to honor traditional but informal political obligations to their Mideastern allies by delivering war materiel. Of considerable concern to the United States was the possible cumulative effect of the mounting Arab-Israeli firefights in and above the desert. Combined with the need to replenish rapidly dwindling ammunition reserves, and the potentially stifling consequences of a threatened oil embargo, together, they foreboded the ominous prospect of "brinkmanship": an escalation of hostilities that could ignite a direct US-Soviet exchange. And it was not long before such a contest promised to provoke a Russian-American shoving match. On 12 October, United States Secretary of State Henry Kissinger warned Americans that Soviet airlifts of new weapons had begun to beef up the military capability of Egyptian and Syrian allies. In turn, worried over Israel's security and its place in the power equation, and after careful deliberation, the United States began to fortify Israeli arsenals. Matters soon worsened. By 25 October, Russia had prepared to use her ground forces to patrol poorly-defined truce lines and a brittle cease-fire. In a countermove, President Richard M. Nixon ordered all US military personnel to a worldwide alert should Soviet soldiers set foot on the fractured Mideastern turf. Ultimately, however, neither power unleashed troops, but jittery observers nevertheless fretted over the menacing buildup of Soviet submarine and US naval fleets in the Mediterranean.[1]

Meanwhile, as visions of empty pumps and inert gasoline lines loomed in the minds of energy seers, and as the advancing Watergate scandal stalked the Presidency, astute American diplomats sketched plans to preserve the peace and contain the Soviets. A critical play, they believed, would be to block Russia from using the Mideastern confusion to enhance its military and political position at the expense of the United States. One of the chief resources available to US strategists to achieve that end, and also to derail the onrush of escalating forces, was America's contingent ability to restock the Israeli war chest. That responsibility, they concluded, properly belonged to the United States Air Force (USAF).[2]

Although it would be the Air Force's Military Airlift Command (MAC) that would transport (dodging flyover restrictions posted by dissenting European allies) Israeli war supplies over Atlantic skyways and cross the Mediterranean into Tel Aviv, it would fall to the Air Force Logistics Command (AFLC) to locate and prepare those goods for airlift. The operation, nicknamed Project Nickel Grass, similar to the historic 1948-49 Berlin Airlift (an early Cold War remedy to unplug the Stalin food blockade), and much like OPERATION

DESERT STORM, would test not only AFLC's ability to meet on demand the combat exigencies of a badgered ally situated one-fourth of the way around the world, but the supply task would also challenge the central AFLC mission to deter aggression through logistical strength. In fact, it would be the enormous American resupply campaign feeding a dauntless Israeli war machine that restored a level Cold War chessboard in the Middle East.[3]

To the Ready

In the early morning hours of 10 October 1973, possibly anticipating the impending airlift, Air Staff officials alerted AFLC and its subordinate Air Materiel Areas (AMAs)—redesignated Air Logistics Centers on 1 April 1974. Until otherwise informed, they were to staff important munition positions with specified personnel 7 days a week, 24 hours a day. A day earlier, in what would be later lamented as one of the gravest military defeats in Israeli history, persistent Egyptian assaults had pried their opponent from a key defensive position known as the Bar Lev line, a series of nearly 100 cement bunkers strung along the Suez Canal. Further, Egypt maintained that it had also crippled 102 Jewish tanks and had shoved the Israeli soldiers back nine miles. To that point, American negotiators had balked at supplying the Israeli state with arms for fear US actions would escalate an already worrisome Soviet intrusion or court the enmity of nervous Arabian oil interests. But under pressure from repeated Israeli requests for aid, US policymakers acted, once convinced that a perpetual Soviet resupply effort might recharge Egyptian and Syrian forces and thereby disrupt Middle Eastern equilibrium. And it seemed to some that the Soviets indeed possessed such a prodigious device. Between 10 and 16 October, on an "around-the-clock airborne conveyer belt," Soviet AN-12 and AN-22 transports had flown 300 supply missions to Egypt and Syria to deliver nearly 5,000 tons of weapons, much of it containing surface-to-air missiles.[4]

Under the leadership of General Jack J. Catton (AFLC Commander, 1972-74), the Command had, by late afternoon 10 October, established a Logistics Readiness Center (LRC). Humming busily with supply and maintenance transactions, it would serve as the nerve junction connecting all AMA logistics until 2200 hours, 14 November 1973, when final American-Israeli airlift efforts would taxi to a halt. Simply stated, AFLC would fill materiel requests issued by the US Departments of State and Defense. To avoid confusion and to streamline operations, Command personnel would not take direct supply orders from Israeli officials, but they would record operational costs and apprise the Air Staff of stockpile reserves depleted by the war. Subsequent organizational tactics were fairly straightforward and well inside the logistics mission. AFLC would locate the needed war supplies, assemble them into planeloads at preselected bases, and notify the Air Staff LRC after the shipments were air ready. From then on, MAC C-5 Galaxies and C-141 Starlifters would shuttle the cargo more than 6,000 miles, first to Lajes Air Base in the Azores to refuel, and then on to Lod International Airport in Tel Aviv, where Israeli handlers would distribute the goods to their field bases.[5]

Airlifter Maintenance Responsibilities

On 14 October, US defense officials directed the Air Force to launch the airlift. While between 12 and 16 October (and throughout the remainder of the operation), the United States had permitted stripped-down, Israeli Boeing 707s and 747s to pick up hundreds of tons of supplies from stateside bases and replenish withering Israeli reserves, the insufficient payload capacity of the blue and white El Al jetliners had necessitated US aid in the combined form of AFLC and MAC support. The civilian planes alone simply could not rapidly transport the required volumes of war goods. Thus, while MAC would furnish and pilot the hulking airlifters, AFLC would support the flights at two levels: airlifter readiness and repair, and the supply of war materiel.[6]

The previous day, 13 October, General Paul K. Carlton, MAC Commander, under a weighty commitment to make available the many transports needed for the trans-Atlantic crossing, had asked AFLC for help. Responding within hours by priority message, General Catton directed all AMA commanders to lend their full assistance, including the authorization of overtime and premium pay, to ready those MAC transports grounded for routine repairs and scheduled maintenance. Soon, by 16 October, regular MAC missions to Tel Aviv had become standard, an accomplishment which had required the recall of all Pacific-region C-5 airlifters to augment the Nickel Grass workload. Consequently, this placed extra demands on AFLC maintenance workers to keep the additional planes airworthy. By 27 October, 4 to 5 C-5 and 12 to 16 C-141 flights a day landed in Tel Aviv, a rigorous regimen that demanded the timely coordination of repair and maintenance work between MAC and AFLC officials. Of the total USAF C-5 (79) and C-141 (276) fleet, an average of 31 Galaxy and 181 Starlifter aircraft remained operationally-ready continuously throughout the month-long Israeli supply effort.[7]

On 28 October, airlift flights began to taper off. The Joint Chiefs of Staff had reduced the number of missions to Tel Aviv. As the urgency to supply immediate Israeli war needs had abated under the heavy stream of the US airlift, US military planners had subsequently opted to rely on MAC ships for future and continuing resupply operations. While this reduction would lift the burden of those AFLC flight-line crews working long hours to maximize the number of air-ready transports, AFLC would still bear the responsibility to coordinate shipments of war materiel between the various stateside aerial ports until they, too, could be eliminated by the airlift's end on 14 November 1973.[8]

Beans, Band-Aids, and Bullets

Suspended by cables of maintenance and repair, the air bridge to Tel Aviv also rested on AFLC's ability to quickly locate the right equipment and spare parts and get them to the proper place. Although earlier supply efforts of previous and simpler wars have been more readily associated with an archaic "beans, band-aids, and bullets" procurement technology, the modern and especially ferocious Middle Eastern war depended on the use, reuse, and expeditious replacement of ultra-sophisticated weaponry and its companion hardware; the Israeli defense effort alone had consumed $952 million worth of planes, armor, and munitions in the first 100 hours of conflict. While Israel surely needed rifles, bombs, and other combat paraphernalia, it most needed jet fighter-bombers, aircraft missiles, tanks, and antitank rockets. By 17 October, approximately 1,400 to 1,600 tons of military supplies arrived every day to sustain the Middle Eastern dispute—half from the Soviets, half from the United States. And the USAF, with American pilots, had hastily ferried 40 F-4 Phantom jets to Israel to replace those downed by air battles and ground fire. As many as 750 tanks from Israel's combined armor inventory had also been destroyed, making the 150 US M-60 tanks eventually airlifted by the AFLC-MAC machine an

absolute necessity. Before the war, Israel owned 488 combat fighters, many of them A-4 Skyhawks and F-4 Phantoms. But within the first few weeks of the conflict, nearly 100 were lost, some in aerial dogfights, but most from Arab surface-to-air missile assaults using Soviet-supplied SA-2s and SA-3s, and the new and untested SA-6. Consequently, Israel needed the right armament to counter the persistent Arab arsenal. American-made Sidewinder, Shrike, and Walleye missiles, capable of knocking out Egyptian fighters, Soviet surface-to-air missile emplacements, and Syrian tanks, soon arrived through AFLC efforts to protect the Middle Eastern power formula.[9]

On a more mundane yet equally vital level, among the first nontactical supplies to touch down in Tel Aviv were replacement windshields and fuel tanks for the F-4. Although usually unsung in the wartime annals of logistics, spare parts such as windshields for the F-4 Phantom were critical to combat operations. For obvious reasons, without a proper windscreen complement to replace battle-damaged counterparts, the otherwise lethal Phantoms sat parked on their tarmacs, frozen like statues. Similarly, extra F-4 wing and centerline fuel tanks, more than 2,000, had also arrived to extend mission lengths. Additionally, nearly 1,000 F-4 main wheel tires, hundreds of multiple and triple ejection bomb racks, assorted electrical items, air conditioners, spark plugs, vehicles, and clothing comprised some of the less-interesting but all-important shipments to Israel.[10]

Support for the F-4 Phantom

Although most of the AFLC airlift support posed few difficulties for logistics personnel, several minor instances surrounding the F-4 did require creative planning. At times during the Nickel Grass operation, in order to protect overall Air Force tactical strength, AFLC had to juggle assets and divert Israeli F-4 repairs to other organizations and recommend substitute replacement parts. One such example involved the KA90A reconnaissance camera. The Air Force owned only three of the expensive and highly specialized units, and all had been mounted on F-4s assigned to the 432nd Tactical Reconnaissance Wing at Udorn AB, Thailand. Worse, support crews required 16 cumbersome man-hours to strip one from a Thailand-based RF-4C model Phantom and transfer it to the Israeli RF-4E edition. Consequently, adapting to the imperfect conditions, AFLC logisticians proposed that crews switch to a KA91 camera as it was commonly used by and readily available in US Air Forces in Europe (USAFE) reconnaissance squadrons. Not only would the time- and money-saving substitution work, but Air Force operational readiness in Southeast Asia would go undisturbed.[11]

Another example of flexible planning during the Yom Kippur War involved the repair of crash- or battle-damaged F-4s. At the time, restoration and maintenance workovers could only be performed at three locations: the Ogden AMA, in Utah; Getafe, Spain; or the Air America facility at Tainan, Taiwan. AFLC strategists advised that the Air America facility was the proper site to rejuvenate the crippled F-4s as both the Ogden and the Spanish shops were overburdened. Further, AFLC assured that Air America could do the work because it had already refurbished 13 Phantoms that year. Although repairs would take place in Taiwan, Air Force personnel and an AFLC representative would oversee the actual appraisal of aircraft damage to Israeli-based, AFLC-supported F-4s.[12]

By the end of the war, AFLC had supported the Israeli-based F-4s in two ways. At one level, maintenance technicians had attended the aircraft en route and while in Israel. On another, AFLC logisticians had looked after those Air Force units which had sacrificed F-4s for the Israeli defense. In some instances, such transfers did weaken combat preparedness. By mid-October, the Air Force's Tactical Air Command (TAC) had moved 30 F-4Es to Israel. As an unavoidable result, the readiness status of some TAC wings slipped due to the reduction in the number of their aircraft. For instance, the 4th and the 33rd Tactical Fighter Wings both dropped respectively to C-4 (not combat ready) and C-3 (marginally combat ready) levels of preparedness.[13]

Munitions Support—Maverick, Shrike, and Sparrow Missiles

Beyond tending the supply and maintenance needs of MAC transports, TAC fighters, and the cursory attention given to a few helicopters, AFLC also located and shipped the stuff of war itself: munitions. The following list reveals the relative importance Israel placed on each munition category:[14]

Priority	*Item*	*Quantity*
1	Tow Launchers	81
2	Tow Missiles	2,000
3	105mm APD Ammunition	90,000
4	105mm HEAT Ammunition	60,000
5	175mm Projectiles	20,000
5a	175mm Primer	40,000
5b	175mm Fuses	40,000
5c	175mm Propellant	20,000
6	LORAN-Aided Weapons	16,000
7	ALQ-119 ECM Pods	70
8	370-Gallon Fuel Tanks	400
9	Cluster Bomb Units	3,000
10	FMU 56 C/B Fuses	8,000
11	Rockeye Bombs	5,000
11a	Walleye Bombs	100
12	Armor Vests	5,000

As the war progressed, the priority list evolved to accommodate the shifting directions of battlefield commanders. One of those alterations included air-to-ground Maverick missiles, the addition of which offered logistics handlers an unsettling dilemma. On 16 October, after the priority list had been established, the Air Force LRC instructed AFLC to route 300 AGM-65A Maverick missiles to Israel. The order also specified that all necessary spares, aerospace ground equipment, and technical information accompany the shipment. While this initial request did not trouble AFLC personnel, their subsequent and now-impaired ability to support other Air Force commands did. At that time, there were only 629 Mavericks available throughout the entire Air Force. Consequently, a delivery of nearly one-half the total Air Force inventory to the Israelis meant a delay in Maverick allotments to Pacific Air Forces (PACAF) and USAFE. Setting this uneasy condition right relied on the ability of the Air Force Maverick System Program Office and the Hughes Aircraft Company (the manufacturer) to hasten the pace of missile production and delivery. As a result, the concerned AMAs had to rethink some of their internal priorities to fill the missile orders, a fact which caused minor setbacks in other programs, such as the Short Range Attack Missile (SRAM).[15]

On 1 November, following an Air Staff directive to expedite with the highest priority 100 additional Mavericks to Israel, the Air Force ordered increased production of the weapon over the next 30 days. In addition, the Hughes Company flew seven technical representatives to Israel in support of the air-to-ground system.[16]

Two other Israeli missile requirements also challenged AFLC to balance its obligations to allies with peacetime logistical commitments. In the first weeks of October, the Jewish state had requested and received 150 air-to-ground Shrikes. By the end of October, Israeli officials had asked for 150 more. The obliging AMA, as a result, told AFLC that by sending the Shrikes to Israel, their war reserve materiel had fallen below acceptable levels. By then, the total available Air Force Shrike inventory had receded to around 75 missiles. Consequently, future, if any, Israeli orders would have to be filled from the operational reserves of USAFE and PACAF. There were, however, 837 other older model Shrikes in storage which could still be used in an emergency.[17]

Like the Shrike, to ship Sparrow missiles to Israel posed allotment problems for AFLC procurement workers—shortages that would also diminish USAFE missile inventories. Although Warner-Robins AMA had furnished 50 Sparrows in late October, it had only been accomplished by scavenging a pending outbound shipment of Sparrow rocket motors slated for USAFE. The impediment was that no new Sparrows were being produced, a fact which had forced the AMA to tap the stockpiles of Air Force operational units. In an effort to counter this uncomfortable reality, AFLC embarked on a program to modernize older rocket motors to replace those bound for Israel.[18]

Electronic Countermeasures (ECM) Support

A critical breach discovered early in Israeli defenses had been the lack of adequate electronic countermeasure technology used to confuse enemy radar. To detect and foil hostile tracking devices, thereby frustrating radar-guided enemy missiles, would be crucial to survival in the ferocious air war over the Sinai.[19]

On 10 October, the fifth day of the conflict, an Air Staff message asked for ECM gear in Israel. Twenty-five radar homing and warning sets, 5 airborne radar receivers, 20 chaff dispensing pods, and 600 loads of mixed-frequency chaff (aluminum strips dumped from pods mounted beneath the F-4 aircraft to deflect enemy radar) were subsequently ordered and sent to Tel Aviv. Similar to the measures AFLC officials used to fill several of the missile orders, the dispensing pods came from USAFE aircraft, a fact which left some European-based US aircraft temporarily short-suited. As Israeli Phantoms rained more and more chaff into the busy and dangerous skies, AFLC received Air Staff authorization to dip into its FY1974 procurement program and spend $3 million to replace its evaporating stocks of chaff.[20]

Costs and Impact

On 14 November 1973, the US closed the pipeline to Tel Aviv. The airlift had ended. In the latter days of October, a truce had been struck. Peace, though a smoldering one, had been restored between the Soviet-backed Arabs and the American-supported Israelis, and AFLC could quite properly take part of the credit. Necessary to world stability, the delicate balance of power in the Mideast had returned to center. Some observers, such as Frank Aker, in his book, *October 1973, The Arab-Israeli War*, would award much of the responsibility for the strong Israeli rally to the US Air Force supply machine, a testament to the AFLC goal of "deterrence through logistics." By 15 November, following 145 C-5 and 421 C-141 missions, and after consuming more than 46 million gallons of fuel, the joint MAC-AFLC airlift had provided over 22,000 tons of supplies to Israel during the 30-day airlift.[21]

Also, because of AFLC's flexible organization and abundant resources, the war had imposed little negative impact on the Command's continuing ability to provide "Combat Strength Through Logistics." In a 15 November congratulatory message, General Carlton expressed his personal gratitude to AFLC. New records in shipment tonnage had been set along with unprecedented reliability rates: 95.7% for the C-5 and 98% for the C-141. Further, due to sound early planning, Air Staff interest, and the fact that much of the materiel sent to Israel had not been sanctioned by any existing Foreign Military Sales account, AFLC had from the start kept a detailed cost ledger on Project Nickel Grass. Seven major cost categories assessed the financial picture: materiel, packing, crating, handling, transportation costs for moving materiel to pick-up points, civilian overtime and travel, and all other related costs, excluding the direct support to MAC C-141 and C-5 transports. The total cost to AFLC for the goods shipped to Israel (minus aircraft) amounted to over $75 million. Overall costs to the Air Force were estimated at almost $392 million.[22]

Despite the AFLC successes, a few supply shortages did emerge along the way. But remarkably, of the 365 various and complicated categories of items that AFLC prepared for Israel, only 73 had diminished by varying degrees the volumes of Air Force war reserves. To gauge the extent of those depletions accurately, procurement officials used three factors: (1) the quantity of the item shipped; (2) AFLC's capacity to support worldwide requirements, based on the number of those articles left shelved in either the Air Force active inventory or reserve stockpiles; and (3) the length of time to recover the materiel losses. Munitions were the usual shortfalls. For example, instead of recouping the reductions in its Rockeye bomb arsenal by February 1975, as originally planned, it took AFLC until August 1976 to restore its extras. By itself, through, the Middle East crisis had little impact on the status of Rockeyes because a shortage had already been noted before the war. The Arab-Israeli conflict only made conditions slightly worse. Aircraft spare parts fell into a similar category. For instance, exhaust indicators for the F-4, in short supply for some time, when shipped to Israel, extended the Air Force recovery date only four months. On the other hand, shipments of spare aircraft engines and their allotment of extra parts had no effect on war reserves at all. This pleasant circumstance was owed to the fact that some engine kits could be substituted for others, as in the case of the T-56 quick change kit.[23]

The only serious shortages occurred within Air Force missile stocks. As previously mentioned, air-to-ground Mavericks, Shrikes, and Sparrows, already precious few in number, had dropped to low levels toward the end of the war. And because the Air Staff itself managed a significant portion of the different missile procurement programs, AFLC had some difficulty in establishing accurate replenishment dates. Not as serious, but nevertheless immediate, some shortages developed following the delivery of ECM components. Consequently, several USAFE and TAC F-4s went without a full ECM complement while AFLC worked to replace them. For example, Air Staff had directed AFLC to restock the 85 ECM pods delivered to Israel at the rate of 20 per month. But, as AFLC discovered in

November 1973, the manufacturing schedule of pods had fallen behind five months. Due to events beyond its control, AFLC would not be able to bring its ECM pod reserves back to strength until February 1975. The only other notable loss to Air Force war reserves involved two radar sets. To meet Israeli needs, AFLC workers had taken the sets from Air National Guard units, a fact which stripped them of prime mission hardware. But logisticians expected to recover even those losses from contractor assets in good time.[24]

In a December 1973 appraisal of the airlift, General Catton noted that Project Nickel Grass had little adverse effect on routine AFLC operations. Emergency reorganization or mass reassignment of personnel had not been necessary for the Command to fulfill the Air Force mission, which was, in his terse but accurate words, to "respond to unprogrammed contingencies." AFLC had once again done its part to keep American air defenses and those of her allies strong.[25]

Now, as war once again erupts in the Mideast, this time pitting the United States and its allies against Iraq for its invasion of Kuwait on 2 August 1990, AFLC continues to respond to "unprogrammed contingencies," richer no doubt from the experiences and lessons learned during the 1973 Yom Kippur War.

Notes

[1]"Mideast War: Any Real Winners?" *U.S. News & World Report*, 5 Nov 1973, pp. 23-28.

[2]For a day-by-day account of developing events in the Arab-Israeli conflict, and the options faced by US strategists, see "Mideast Explodes Again," *U.S. News & World Report*, 22 Oct 1973, pp. 26-28; "Mideast: How Far Will Nixon Go?" *U.S. News & World Report*, 29 Oct 1973, pp. 14-23; "Mideast War: Any Real Winners?" *U.S. News & World Report*, 5 Nov 1973, pp. 23-28.

[3]Aker, Frank. *October 1973: The Arab-Israeli War* (Archon Books: Hamden, CT), 1985, pp. 31-34.

[4]Msg, CSAF to AFLC et al, 102337Z Oct 1973, Subj: Munitions Movements; "Mideast Explodes Again," p. 28, "Mideast: How Far Will Nixon Go?" p. 15.

[5]Ltr & atchs, MMI Readiness Center to DCS/MM, 12 Oct 1973, Subj: Activity Rpt; Msg, LRC, AFLC, to all AMAs et al, 141955Z Nov 1973, Subj: Deactivation of HQ AF/LRC.

[6]Msg, 2750 ABW to CSAF, 232235Z Oct 1973, Subj: Airlift for Project Nickel Grass; Msg, MAC to AFLC, 151855Z Oct 1973, Subj: MAC Sitrep.

[7]Msg, AFLC to all AMAs, 132115Z Oct 1973, Subj: Support to MAC; Msg, AFLC to MAC, 132117Z Oct 1973, Subj: Support to MAC; Msg, MAC to AFLC, 131800Z Oct 1973, Subj: Support to MAC; Msg, CSAF to AFLC et al, 271253Z Oct 1973, Subj: Sea and Airlift Shipments of Project Nickel Grass/9DD Mat; AFLC Hist Study No 384, "AFLC Support of Proj Nickel Grass/99D, 10 Oct 1973-14 Nov 1973," Vol II, pp. 7-8.

[8]Msg, CSAF to AFLC et al, 271253Z Oct 1973, Subj: Sea and Airlift Shipments of Proj Nickel Grass/99D.

[9]Sobel, Lester A., ed. *Israel and the Arabs—The October 1973 War* (Facts on File: New York), 1974, pp. 101-102; "Mideast: How Far Will Nixon Go?" p. 15; "Mideast Explodes Again," p. 27.

[10]Msg, CSAF to OOAMA, 100747Z Oct 1973, Subj: Req for Availability of F4E Parts; MSG, OOAMA to AFLC, 112350Z Oct 1973, Subj: F-4E Windshields, Stabilators, and Wing Panels; "Movement Summary, Proj Nickel Grass-99D," 14 Nov 1973; Msg, WRAMA to CSAF, 141100Z Oct 1973, Subj: Airlift Support; Msg, AFLC to SAAMA, 181050Z Oct 1973, Subj: Harvest Eagle Runway Set.

[11]Msg, AFLC to CSAF, 220150Z Oct 1973, Subj: Mat Movement.

[12]Msg, D/MM, OOAMA to AFLC, 302000Z Oct 1973, Subj: Repair of CBD Acft; Msg, AFLC to CSAF, 070415Z Nov 1973, Subj: Status of CBD Aircraft.

[13]AFLC Hist Study No 384, Vol II, p. 15; Msg, TAC to AFLC, 171815Z Oct 1973, Subj: Acft Transfers; Msg, TAC to AFLC, 232035Z Oct 1973, Subj: Transfers.

[14]Msg, CSAF to AFLC, 160737Z Oct 1973, Subj: Mat Movement.

[15]Msg, CSAF to AFLC et al, 170129Z Oct 1973, Subj: Mat Movement; Msg, CSAF to AFLC, 171707Z Oct 1973, Subj: Mat Movement; Msg, D/MM, OOAMA to AFLC et al, 182240Z Oct 1973, Subj: Proj 99/D Support; Ltr, Dir Int Log LRC, to AFLC/CC, 16 Oct 1973, Subj: Activity Report Proj 99/D.

[16]Msg, CSAF to AFLC et al, 012135Z Nov 1973, Subj: Mun Support; Msg, CSAF to USDAO, Tel Aviv 051228Z Nov 1973, Subj: Proj Nickel Grass; Msg, AFLC to CSAF, 220645Z Oct 1973, Subj: Control of Mil and OSD Sponsored Civ Pers.

[17]Msg, WRAMA to AFLC, 292210Z Oct 1973, Subj: Impact Statement.

[18]Ibid.

[19]Allen, Peter. *The Yom Kippur War* (Charles Scribner's Sons: New York), 1982, p. 209.

[20]Msg, CSAF to AFLC, 100653Z Oct 1973, Subj: Preparation for Movement Order; Briefing, "Proj Nickel Grass," prep by Dir Internatl Log, 19 Oct 1973; Msg, CSAF to AFSC & AFLC, 122246Z Oct 1973, Subj: Chaff Prod; Msg, AFLC to AFSC, 152029Z Oct 1973, Subj; Proc of ALE-38 Chaff.

[21]Aker, *October 1973, The Arab-Israeli War*, pp. 31-34; Msg, MAC to AFLC, 152305Z Nov 1973, Subj: AFLC Support; AFLC Hist Study No 384, Vol I, p. 168.

[22]Msg, AFLC to All AMAs et al, 122200Z Oct 1973, Subj: Proj Code 99/D; Msg, CSAF to AFLC et al, 232218Z Oct 1973, Subj: U.S. Budgetary Costs Arising from the Middle East Conflict; Msg, AFLC to all AMAs et al, 161742Z Oct 1973, Subj: Mat Movement; AFLC Hist Study No. 384, Vol II, p. 21.

[23]Summary, "Impact Assessment of AF Inventory Posture Resulting from Proj Nickel Grass-(9DD)," prep by Stock Fund Div, Dir Mat Reqs, DCS/MM, 15 Nov 1973.

[24]Ibid., pp. D-1, D-2, C-1 to C-5, H-1, H-2.

[25]"The Special Delivery War," *Dayton Journal Herald*, 10 Dec 1973.

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[29]Federal Register, Vol. 53, No. 213, November 3, 1988, pp. 44564-44567.

[30]Setzer, Steven W. "Bonding Crunch Hits Contractors," *Engineering News Record (ENR)*, January 22, 1987, p. 132.

[31]Telephone Interview with Ms. Eileen Foley, Department of the Treasury, Financial Management Division, Washington DC, August 1986.

[32]Setzer, "Bonding Crunch Hits Contractors," p. 132.

[33]Telephone Interview with Mr. Howard Huegel, Small Business Administration, Director, Office of Surety Guarantees, Arlington, Virginia, May 1988.

[34]Selick, Brent L. ASBCA 21869, cited in the Government Contractor, Vol. 21, Sect. 12.

[35]Department of the Air Force. *Government Contract Law*, 4th Ed., Air Force Institute of Technology: Wright-Patterson AFB OH, 1979, p. 157.

[36]Hoe, E. Sanderson. "The Contracting Process" (Chapter of Course Manual entitled "Working with the FAR," Federal Publications, Inc., Washington DC, 1985), p. D-66.

[37]Hinchey, "Payment and Performance Bond Coverages and Claims," p. 31.

[38]Department of the Air Force, *Contract Administration*, p. 112.

[39]Hinchey, "Payment and Performance Bond Coverages and Claims," p. 33.

[40]U.S. General Accounting Office, *Use of Surety Bonds In Federal Construction Contracts Should Be Improved*, Report No. LCD-74-319, pp. 25-26.

[41]U.S. Department of Agriculture, Forest Service, F.S. Handbook 6509.11k, Interim Directive 27, dated March 25, 1987.

[42]Defense Audit Service, *Report on the Review of Contract Terminations*, p. 2.

[43]Air Force Form 3056, May 1978.

[44]Naval Education and Training Program Development Center, *Financial Management in the Navy*, NAVEDTRA 10792-E (Washington DC: Government Printing Office, 1981), pp. 11-31.

[45]Ibid., pp. 11-32.

[46]Knittle and Carr, "Detection and Avoidance of Contractor Defaults," p. 108.

Air Force Human Resources Laboratory FY90-91 Logistics R&D Program

The Air Force Human Resources Laboratory, Logistics and Human Factors Division, Wright-Patterson Air Force Base, Ohio, is the principal organization which plans and executes the USAF exploratory and advanced development programs in the areas of Combat Logistics, Acquisition Logistics, and Team Training Systems. Most of the Laboratory's efforts to improve Air Force logistics are managed within these sub-thrusts areas. Some efforts are undertaken in response to technology needs identified by the Laboratory, but the majority of the work is in response to formally stated requirements from various commands and staff agencies within the Air Force. Many of our projects vary from basic research aimed at producing new fundamental knowledge to applied projects which are intended to demonstrate the technical feasibility and military effectiveness of a proposed concept or technique.

Following are some logistics R&D projects managed by the Logistics and Human Factors Division, which will be active during FY90 and FY91. (Contact: Colonel James C. Clark, AUTOVON 785-3713, (513) 255-6797)

INTEGRATED MAINTENANCE INFORMATION SYSTEM (IMIS)

OBJECTIVE: To develop a prototype integrated information system for the flight-line maintenance technician which will provide all the diagnostic, technical order, training, and work management data needed for job performance.

APPROACH: A series of design studies and prototype field tests will be conducted to establish the display formats, man-computer interface, and information requirements for IMIS. Structured analysis techniques will be used to define information requirements for the system. The results of the analysis will provide the basis for design of the system. A prototype IMIS will be developed and evaluated in an operational environment. The prototype will be field-tested to evaluate the design requirements for integrating and displaying maintenance information. Specifications will be developed for use in procuring IMIS for operational application. (Mr Richard Weimer, LRC, AUTOVON 785-2606, (513) 255-2606)

INTEGRATED MAINTENANCE INFORMATION SYSTEM (IMIS) DIAGNOSTIC DEMONSTRATION

OBJECTIVE: To evaluate the capability of maintenance technicians to perform complex on-equipment diagnostic tasks, and the associated remove-and-replace tasks, using an automated technical order system containing improved technical data.

APPROACH: A prototype portable computer has been developed that plugs into the maintenance bus on advanced aircraft. This portable aid will download the built-in test data that resides on the bus and then will incorporate that data into the diagnostic algorithm contained in memory. The technician will be given the next best test until the fault is found. Then remove-and-replace instructions will be provided at the appropriate level of detail for the technician. Two organizational level demonstrations are included in the program. The first demonstration was conducted at Homestead Air Force Base in May 1989 using the F-16A/B aircraft fire control radar as the testbed. A small sample set of faults was inserted on the aircraft. The prototype portable aid with improved technical data, including diagnostics, assisted the technicians in performing the fault detection/isolation and the necessary corrective actions. The second demonstration will be with the Navy's F/A-18 aircraft in May 1991. Improved technical data and presentation systems will be incorporated into the portable aid, based on the learning experience of the F-16 demonstration. The sophistication of the built-in test capability on the F/A-18 will permit a field test that demonstrates the future potential of advanced, job-aided, interactive, on-equipment diagnostics. (Capt Mike Seus, LRC, AUTOVON 785-2606, (513) 255-2606)

CONTENT DATA MODEL (CDM)

OBJECTIVE: To develop an interchange specification for exchanging integrated databases for technical data for maintenance. The CDM will provide the basis for interchanging maintenance technical data that is free of redundancies and contains no format information. Data maintained in the CDM can be presented on a variety of computer systems or printed in a variety of formats without any change to the database itself. This feature will make it possible to take advantage of advances in information presentation systems without having to redo the data to make it compatible with the new systems.

APPROACH: Development, field demonstrations, and tests of draft specifications for authoring of "Type C" digital aircraft maintenance technical information in an open architecture, format free, neutral database style. (Mr David Gunning, LRC, AUTOVON 785-2606 (513) 255-2606)

DESIGN EVALUATION FOR PERSONNEL, TRAINING AND HUMAN (DEPTH) FACTORS

OBJECTIVE: To use existing computer-aided design (CAD) man-model technology and incorporate information relevant to Logistics Support Analysis (LSA), personnel, and training. This is a new direction in the use of computer graphics man-modeling.

APPROACH: Through simulations on CAD designs, the DEPTH user will be able to determine human factors and human resource requirements with respect to maintainability. These simulations will make such analyses easier and more accurate than current methods. The software will be housed in a computer graphic workstation and will be able to import CAD data. Designs can be displayed with surfaced images in three-dimensional space and will be capable of real-time manipulation. The program will "understand" how to construct maintenance tasks when given high-level commands from the user. Animation will be used to display results. Crew Chief, a man-model developed by the Air Force Human Resources Laboratory (AFHRL) and the Armstrong Aerospace Medical Research Laboratory (AAMRL), will be the baseline for the ergonomic capabilities within DEPTH. (Mr Ed Boyle, LRL, AUTOVON 785-3871, (513) 255-3871)

Continued in Spring Issue

CAREER AND PERSONNEL INFORMATION

Logistics Professional Development

Squadron Commander Selection Process

This past year, the logistics force gained more than 500 new majors. The majority are itching to be squadron commanders, but they do not know how selections are made. The squadron commander process is not a dark mystery; in fact, it is pretty simple:

Officers are selected as candidates for possible squadron commander billets through either formal or informal MAJCOM boards. USAFE, TAC, SAC, and MAC all have formal squadron commander boards which are usually held every six months (in the spring and in the fall).

HQ AFMPC ensures that all logistics officers worldwide have the same opportunity to compete for squadron commander positions. The Center provides each MAJCOM with a list of all officers eligible to move under present PCS rules and are within the eligibility window (for officers who are eligible to move in the next 18 months from date, data is provided). Major selectees through lieutenant colonels are considered. Prior to an upcoming majors board, captains who are in the prime zone to major are also included.

Up to this point, the computer has done all the work. A manual scrub is then done to ensure no one has been missed. In the process, no distinction is made relative to present MAJCOM or background; each MAJCOM will see all the available officers in MAC, TAC, SAC, USAFE, PACAF, AFLC, SOAs, senior and intermediate service schools, etc. HQ AFMPC does not make any decisions on "who should or should not" make this "macro" list. It is strictly a function of grade, availability to move, and quality of force indicators (UIF, weight management, etc.). The MAJCOMs are then given access to this database.

MAJCOMs review the candidates and determine which ones they will consider before a board. Some MAJCOMs board three times as many candidates as they project requirements for. This includes officers who are available to move to both CONUS and overseas commander requirements. Officers who are not eligible to move may be boarded if the wing commander makes a recommendation to their respective MAJCOM. The board then considers candidates recommended from both a worldwide HQ AFMPC database, as well as those nominated by wing commanders. For those officers assigned outside the boarding MAJCOM, a copy of their selection folders on microfiche, along with a copy of the most recent AF Form 90, will be forwarded from HQ AFMPC. (NOTE: This is one of the few times the AF Form 90 meets a formal board, so it needs to be as current as an officer's photo.)

Once the boards complete this process, a selection list is produced which is then approved by the MAJCOM commander. Once approved, HQ AFMPC and the MAJCOMs use the list to nominate candidates to the individual wing commanders needing replacement squadron commanders. In some cases, MAJCOMs provide information copies to other commands; i.e., TAC usually provides an info copy to both PACAF and USAFE. If an individual is not on the MAJCOM list, chances of being a commander are slim.

Now, what can officers do to make sure they have an opportunity to meet and be selected by the MAJCOM boards? By far and most important, they should make sure their records are accurate and up-to-date, including their AF Form 90. Believe it or not, we have people who meet the MAJCOM boards with photos and AF Forms 90 that are over five years old. This does not give a good first impression to the board members! HQ AFMPC provides the candidate databases to the MAJCOMs in April and October of each year. If officers have more than two years on station, or are completing a controlled tour, they should be on this list. Individuals should remember, if they do not meet the criteria for PCSing, they need their wing commander's recommendation to be considered by their MAJCOM.

With the changes in the entire Air Force structure, including a continued decline in the rated supplement presence in almost all MAJCOMs, the need for quality officers as squadron commanders is increasing. Quality officers are in demand. In fact, there are several logistics officers on the SAC and MAC commanders lists who have never worked in those commands before.

If you have questions concerning the squadron commander process, call your Palace Log assignments team at HQ AFMPC:

Aircraft Maintenance/Munitions	AUTOVON 487-3556
Transportation	AUTOVON 487-4024
Supply	AUTOVON 487-6417
Logistics Plans/Programs	AUTOVON 487-5788
Missile Maintenance	AUTOVON 487-5207

(Maj Tom Billig, AFMPC/DPMRSL, AUTOVON 487-3556)

(The department, "Civilian Career Management," will resume in the Spring issue.)

Best Article Written by a Junior Officer

The Executive Board of the Society of Logistics Engineers (SOLE) Chapter, Montgomery, Alabama, has selected "Integrating Logistics Reality Into Command Post Exercises" (Winter 1990), written by Captain Russell S. Hall, USAF, in collaboration with Lieutenant Colonel Phillip E. Miller, USAF, as the best *AFJL* article written by a junior officer for FY90.

(The Most Significant Article Award for the Fall 1990 issue will be published in the Spring issue.)

(The following item describes the 1990 PASOLS to acquaint our readers with the purpose of this unique forum for senior level logisticians. The next meeting will be in April 1991.)

PASOLS: Defining Pacific "Logistics for the 1990s"

"In the past few years it seems each Pacific Area Senior Officer Logistics Seminar (PASOLS) somehow gets even better than the outstanding one that preceded it." Quotes such as these were common at the conclusion of PASOLS XIX hosted 18-24 February 1990 by the Royal Thai Armed Forces in Bangkok. This conference drew the largest participation since PASOLS' inception in 1971—95 senior delegates (33 general officer level) from 22 attending nations.

PASOLS has been a real success story. It is an apolitical forum of senior level logisticians from many countries in the Pacific-Indian Ocean region. In fact, it is the only multinational, multiservice, and defense ministry level forum in the Pacific region. However, PASOLS has changed significantly since 1971, when eight countries represented by 23 Army-only delegates discussed logistics in relation to the Vietnam War. Now nearly triple that number of countries, from Canada to Mauritius in the Indian Ocean, discuss peacetime objectives such as nation building and regional cooperation. There are 12 member nations who extend invitations each year to other nations to attend in an observer status. Designed as an academic seminar for practicing logisticians, the goals of the organization have been to further each country's self-sufficiency, strengthen attendees' logistics management capabilities, foster regional logistics cooperation, and pursue mutually agreed to initiatives. However, the key to its success has been that it is conducted in an atmosphere conducive to cooperation, thereby encouraging the mutual exchange of problems, solutions, and concepts.

The Thai people have a long history of being gracious hosts and this seminar was certainly a testimony to that tradition. As delegates arrived at the airport, they began a continuous process of being cared for in first-class fashion. The opening ceremonies commenced as Co-Chairmen Vice Admiral Chatchawarn Khongdis, Director of Joint Logistics, Royal Thai Supreme Command Headquarters, and Rear Admiral Robert L. Toney, Director of Logistics-Security Assistance, U.S. Pacific Command, welcomed the delegates and in-country ambassadors and defense attaches.

The theme was "Logistics in the 1990s" and focused on future common logistics problems and opportunities. It provided the delegates with meaningful issues which had application to all nations, regardless of their size or stage of development. Two inspiring keynote addresses were made by General Chavalit Yongchaiyudh, Acting Supreme Commander, Royal Thai Armed Forces (RTARF) and Admiral Huntington Hardisty, Commander in Chief, U.S. Pacific Command. These two special presentations set the tone and motivation level for the seminar.

Following this auspicious beginning, PASOLS began an aggressive schedule. The next day-and-a-half was devoted to 17 presentations delivered by delegates, followed by question and answer sessions. This was followed by a-day-and-a-half of panel discussions which make up the heart of PASOLS. These panels provide the medium for the free, open exchange of logistics ideas and dialogue.

The panels discussed four topics: Managing Resource Constraints, chaired by Mr Ray N. Sturgeon from Canada; Automation in Logistics Management, chaired by Major General John Grey from Australia; Civilian Infrastructure Development, chaired by Mr James M. Compton from the US; and Regional Logistics Cooperation, chaired by Major General Vinai Tansri from Thailand. The panel discussions were lively and all participants contributed significantly. As a result, the panels generated numerous initiatives for follow-on development.

- Developing a compendium which describes how to access each nation's system for disposing of excess property.
- Publishing in the new PASOLS newsletter, *PASOLS LOG*, the logistics activities each country participates in as a result of PASOLS activities.
- Developing a software program to exchange information between countries on the availability of surplus spare parts and support equipment.
- Developing a compendium of national ADP logistics projects and new ADP logistics systems.
- Distributing an information package on Computer Aided Acquisition Logistics Support (CALS).

In the past, PASOLS initiatives have brought about the Thai War Reserve Stockpile; developed publications such as the *Freight Forwarder Guidebook*, *International Logistics Handbook*, and the *International Logistics Communications Systems Handbook*; developed the Consolidated Fuels List for the Pacific; and developed compendiums of logistics courses and exercises available to PASOLS countries.

After four days of hard work, the delegates were rewarded by a Thai hosted C-130 tour of some of Thailand's logistics points of interest. Delegates flew to tour the F-16 logistics support of Wing 1, Royal Thai Air Force, at Korat AB and a city tour of Chiang Mai. The tours proved to be the highlight of a week that was full of highlights.

Throughout the week, individual delegates took advantage of the numerous social activities such as the joint US-Thai sponsored opening reception; luncheons hosted by individual Thai Services; a dinner hosted by General Sundhara Kongsompong, Joint Chief of Staff, RTARF; a dinner hosted by the visiting delegates; and an exquisite evening dinner aboard the Oriental Queen while touring the Chao Phraya River, compliments of the RTARF Acting Supreme Commander. These occasions provided opportunities for delegates to discuss bilateral issues other than those directly tied to PASOLS. In addition, they greatly enhanced, and provided a balance to, the business side of the seminar as delegates developed closer working relationships.

Without a doubt, the seminar was a success—primarily due to the cooperative working relationships developed by the delegates. Indicative of this positive atmosphere were the numerous unsolicited comments of observer nation delegates expressing sincere appreciation for the opportunity to attend, and the numerous outside normal seminar hours expended by many delegates to ensure all business was accomplished.

Through all of the activities—presentations, seminar discussions, initiatives, tours, and side issues—the spirit of cooperation clearly established PASOLS XIX as a benchmark in the history of PASOLS and reaffirmed its tremendous value for the continued peace and prosperity of the Pacific region.

This, of course, set a very tough standard for the upcoming PASOLS XX, which will be hosted by Canada in the beautiful setting of Vancouver from 14-20 April 1991. The theme will be "Logisticians-Meeting the Challenge of Dramatic Change," a very appropriate one for the coming times.

Lieutenant Colonel Bob Bayless, USAF
International Logistics Officer
Headquarters U.S. Pacific Command
Camp H. M. Smith, Hawaii

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